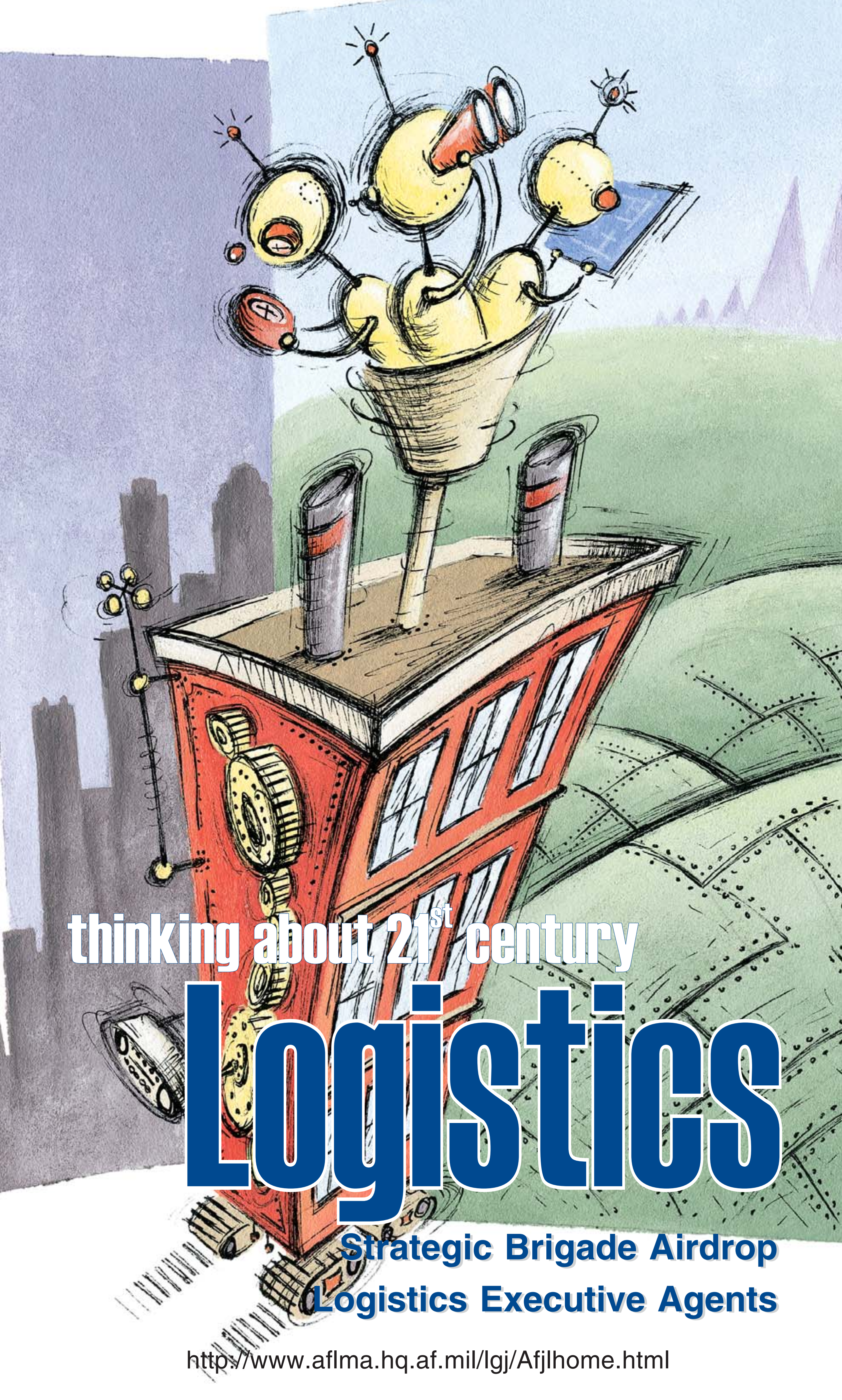

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Strategic Brigade Airdrop

Logistics Executive Agents

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Special Feature

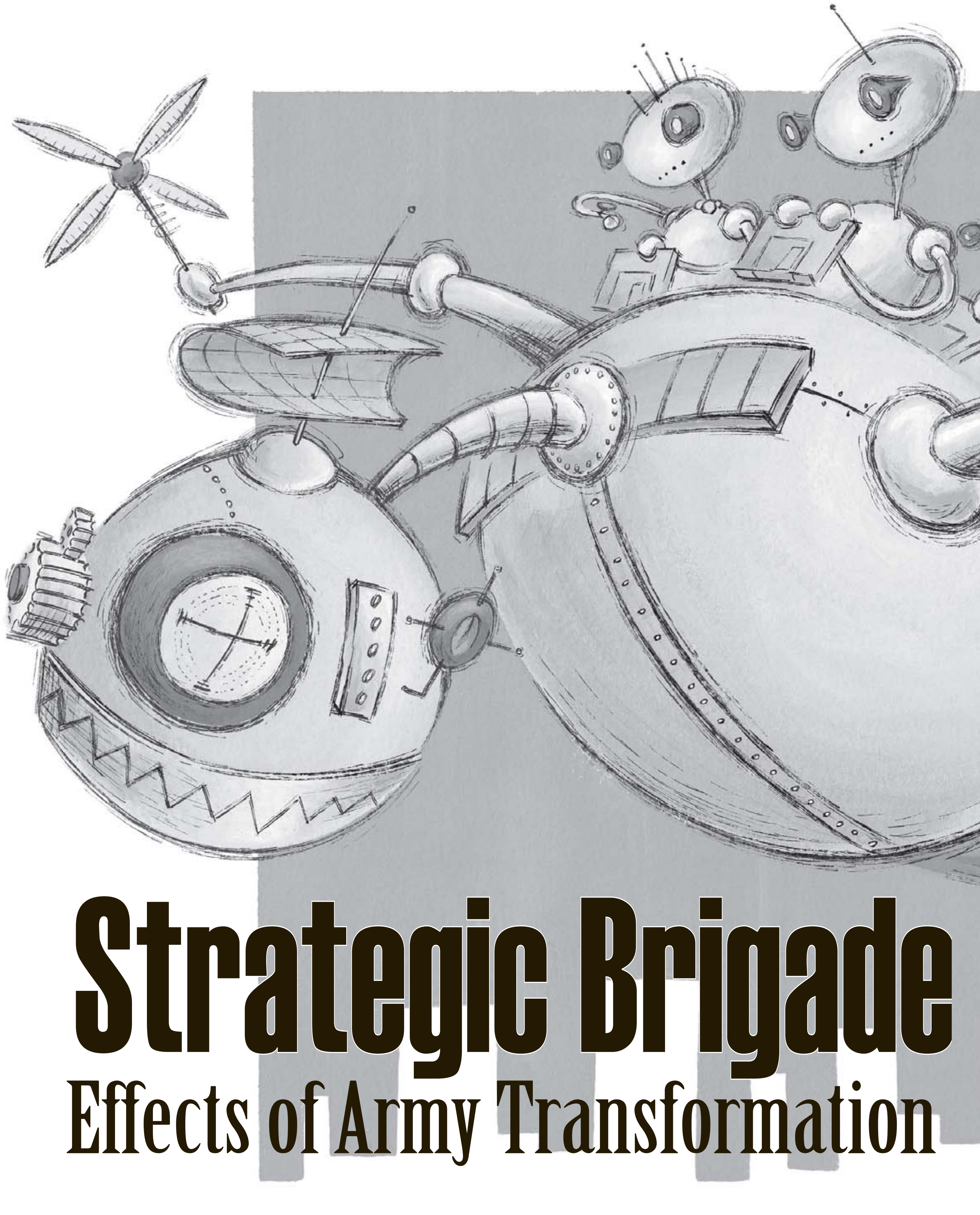
Transformation permeates today's Army. The post-Cold War environment prompted the Service to examine its roles, mission, and structure during the 1990s. The 11 September attacks and Operations Enduring Freedom and Iraqi Freedom accelerated these activities.

thinking about 21st century logistics

Strategic Brigade Airdrop: Effects of Army Transformation and Modularity

Logistics Executive Agents: Enhancing Support to the Joint Warfighter

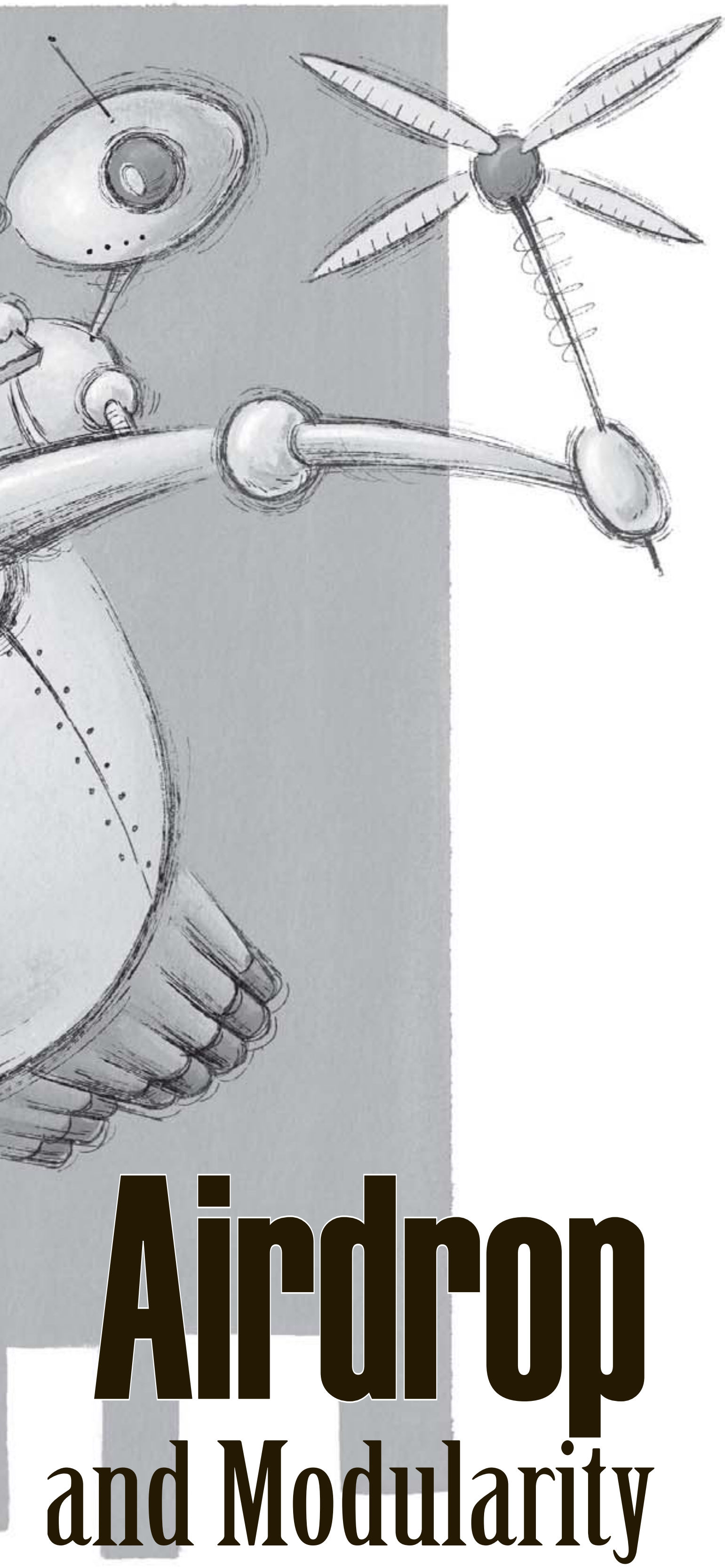
With the close of the 20th century a new era continued to emerge within the US military. Methods used during the Cold War have proven to be both cumbersome and ineffective in meeting the demands of the 21st century. The *old way* is no way to face the new threats and challenges of today's military. Today's forces must be more responsive to particular threats, as well as the theater to which they are being deployed. The first article looks at the Army's process of transforming to better meet the challenges of the 21st century. Areas of focus include the restructure of forces to a modular design, capable of *plugging* and *unplugging* from specific ongoing operations. At the same time, the Air Force is looking for ways to meet the Army's requirements for delivering such a capability. Both of the Services are working together to ensure that a flexible, capable force can be delivered within the parameters required. The second article examines executive agents and their role in support of the joint warfighter. A major theme of the article is efficiency of the supply chain and the *logistics footprint*. Efficiency is critical to supporting light, lean, and lethal forces.



Strategic Brigade

Effects of Army Transformation

Lieutenant Colonel Brian E. O'Connor, USAF
Colonel Stephen O. Fought, PhD, USAF, Retired



Airdrop and Modularity

Special Feature

Introduction

On March 26, 2003, more than 1,000 soldiers of the 173d Airborne Brigade parachuted from 12 Boeing C-17 Globemaster III aircraft into northern Iraq, 8 days after the initiation of Operation Iraqi Freedom. Assigned to the US Army Southern European Task Force, the *Sky Soldiers* parachuted into Iraq to secure the strategically situated Bashur Airfield and to assist special operations forces in deterring the following.

- Iraqi operations against the Kurdish-held region
- Factional fighting among regional Kurdish tribes
- Intervention into Iraq by Turkey[1, 2]

During the next 96 hours, C-17s airlifted the second echelon of the brigade's forces into Bashur, consisting of over 400 vehicles, 2,000 soldiers, and 3,000 tons of equipment.[3]

The airdrop of the 173d Brigade into Iraq was the largest American airborne operation since Operation Just Cause, the invasion of Panama in 1989.[4] A complete success in terms of execution and objectives achieved, this large-scale combat airborne operation constitutes what is known within joint doctrine as a strategic brigade airdrop (SBA). SBA has long been a part of US military capability but known by different names. SBA has in recent years received significant attention within the Army and Air Mobility Command (AMC). The focus of this attention is AMC's inability to execute SBA within specified Army timing parameters and the measures it has taken to meet those requirements. Army transformation and its concept of modularity presents new dimensions that may affect the nature and execution of SBA as well as AMC's multifaceted program to satisfy Army requirements for SBA.

Transformation permeates today's Army. The post-Cold War environment prompted the Service to examine its roles, mission, and structure during the 1990s, which the September 11th attacks and Operations Enduring Freedom and Iraqi Freedom accelerated. The Army recognized that its heavy force orientation constrained its ability to meet current and future probable threats and initiated a Service-wide agenda to transform itself into a more capable and responsive force. Service structure, unit organization, equipment, and personnel now fall under various transformation initiatives and programs—a number of which may directly affect SBA operations.

Modularity is the Army's concept of reorganizing its division-based combat force structure into one that is brigade-based. The

Article Acronyms

ADS – Aerial Delivery System
AMC – Air Mobility Command
AMMP – Air Mobility Master Plan
BCT – Brigade Combat Teams
CDS – Container Delivery System
DRAS – Dual-Row Airdrop System
DRB – Division Ready Brigade
FCS – Future Combat System
FFS – Formation Flight System
IAV – Interim Armored Vehicle
IPT – Integrated Process Team
ISR – Intelligence, Surveillance, and Reconnaissance
JPADS – Joint Precision Airdrop System
MANPAD – Man-Portable Air Defense
MSL – Mean Seal Level
NSC – Army Natick Soldier Center
PEGASYS – Precision Extended Glide Airdrop System
SBA – Strategic Brigade Airdrop
SBCT – Stryker Brigade Combat Team
SKE – Station-Keeping equipment
SKE-FO – Station-Keeping Equipment Follow-On
SPO – System Program Office
TCAS –Traffic Alert and Collision Avoidance System
TOT– Time over Target
UE – Units of Employment

goal of modularity is to "obtain a more relevant and ready campaign-quality Army" that better serves joint requirements.[5] Change within the Army will be far-reaching and among the many possible consequences of modularization are modifications to the composition and execution of SBA. While the Army wrestles with this process, Air Mobility Command has the responsibility of determining how to execute whatever changes are implemented to SBA operations.

SBA – Doctrine and Practice

SBA in Joint Doctrine

Airborne operations have been integral to American military strategy and force structure for 7 decades. Although the strategy, doctrine, and capabilities for airborne forces have varied over the years, there has always been a requirement for the capability to execute large airborne combat operations. Referencing current guidance, SBA falls within the domain of early-entry capabilities in the *2004 National Military Strategy* and *forcible entry operations* in joint guidance.[6] Joint Publication 3-18, *Forcible Entry Operations*, defines forcible entry as "seizing and holding a military lodgment in the face of armed opposition."[7] Joint Publication 3-17, *Tactics, Techniques, and Procedures for Air Mobility Operations*, categorizes SBA as a specific forcible entry capability.[8] Numerous other documents detail aspects of forcible- entry. For instance, United States Joint Forces Command produced the *Joint Forcible-Entry Operations, Joint Enabling Concept* in 2004 to provide joint commanders a set of principles and capabilities to consider for forcible-entry operations through at least 2015.

As the enabler of SBA, the Air Force imparts its doctrinal say in Air Force Doctrine Documents 2-6, *Air Mobility Operations,* 2-6.1, *Airlift Operations*, and 2-6.2, *Air Refueling Operations*. Ultimately, it is AMC's responsibility to execute SBA and it resources that responsibility in its *Air Mobility Master Plan* (AMMP). According to AMMP, mobility air forces must be able to "airdrop a brigade-size force over strategic distances and sustain combat forces by aerial delivery or airland operations."[9] Rather than redundantly discuss how various Army publications cover forcible entry and SBA, it is now possible to examine what the Army actually plans for and requires of the Air Force to execute SBA operations.

SBA Defined

In 1980, the requirement for strategic brigade airdrop was levied by a Joint Chiefs of Staff memorandum.[10] In 1997, the Army and Air Force formed a joint integrated process team (IPT) to examine SBA in light of several dynamics facing both Services. First, the composition and capability of the AMC strategic air fleet was changing—C-17s were entering the inventory in greater numbers and C-141s were being retired. Second, the Army began its introspective path towards transformation and was scrutinizing its roles and missions. Third, the changing international environment and threats to the United States merited a joint look at SBA.[11]

Two future Chiefs of Staff (Lieutenant General Jumper-Air Force, Lieutenant General Shinseki-Army) chaired the IPT, which made a number of determinations. Among the most significant determinations were the following.

- Intercontinental distances, assumed compressed mission timeline, and force protection issues precluded the general use of staging bases. SBA can be conducted within a theater, as was the case of the airdrop and deployment of the 173d Airborne Brigade into Iraq, however the baseline scenario is one conducted from an intercontinental distance.

- Intercontinental distances precluded the use of C-130 aircraft. The use of alternative aircraft, such as the C-130 for SBA, is not addressed within this article.[12]
- SBA is planned for use at or near a short, austere airfield. Such an airfield is loosely defined as a hard or semiprepared airfield, which is too short to accommodate C-141, C-5, or other heavy lift aircraft. As a result,
- SBA will be accomplished by C-17 aircraft only. Since this 1997 IPT decision, the Air Force has contracted for 180 C-17s and is likely to increase the current total. Headquarters AMC also ceased discussions of using other aircraft to execute or assist in executing SBA. Based on these factors, the use of any other aircraft to augment the C-17 in executing SBA will not be discussed.
- The maximum on ground at the airfield is four C-17s. This item, along with the previous and last item, raise an aspect of SBA not mentioned yet. SBA, in fact, comprises two echelons of combat forces insertion—an initial echelon of airdrop and a follow-on echelon of troops and equipment airlanded to a target airfield.
- The airdrop portion of the SBA must be completed within 30 minutes of the time over target (TOT).[13] Hereafter, this period of time will be referred to as *pass time*.
- The airland portion of the SBA commences no later than 4 hours after the airdrop TOT and concludes no later than 24 hours after the TOT.

SBA – The Army's Perspective

Strategic brigade airdrop is a method of employing Army forces into combat. This mission belongs to the 82d Airborne Division of the 18th Airborne Corps. As the lead agent for SBA, the 82d has had the responsibility of devising the composition of SBA since the late 1980s. In conjunction with the higher-level doctrine discussed previously, the 82d approaches SBA using this statement of work: "Within 18 hours of notification, the 82d strategically deploys and conducts forcible-entry parachute assaults to secure key objectives for follow-on military operations in support of US national interests."[14]

The division ready brigade (DRB) is the means by which the 82d executes SBA. The DRB concept is based upon the division's three-brigade organization and comprises a three-cycle rotation of each brigade. Each cycle is 6 weeks in duration. One brigade, known as mission DRB1, is fully trained, mission-ready, and on the hook for deployment within 18 hours. A second brigade, known as training DRB2, is in a training phase during which it trains and prepares for its operational mission. This training includes events accomplished at home station and away from home station. Examples of off-station training are participation in Louisiana's Joint Readiness Training Center, California's National Training Center, and joint task force exercises. The third brigade is the Support DRB3 and is in a stand-down mode in which personnel are on leave, attending school, or assisting with post support activities.[15] Each of the three brigades and battalions within those brigades, abide by specific recall windows. Using baseball vernacular, DRB1 is at bat, DRB2 is on deck, and DRB3 is in the hole.

Article Highlights

Strategic Brigade Airdrop is a method of employing Army forces into combat.

This article examines the effects of Army transformation and modularization on SBA. The first section looks at the joint and Service doctrinal foundations of SBA. It also includes a discussion of the Army's parameters for SBA and a description of a notional SBA as it currently exists. The next section details the challenges of accomplishing SBA, and the programs AMC is working to overcome those challenges. The following section describes Army transformation and modularity in greater detail and their possible impact on SBA. The last section examines the implications for SBA given the proposed direction of modularity. Since the Army's march towards modularization is in a dynamic state of simultaneous theory development and implementation, it concludes with a discussion of the probable consequences of Army actions and offers recommendations as to how AMC can optimize SBA for the Army.

Alpha Echelon – Airdrop Package		
1 Brigade HQ	Troops	2,460
	105mm Howitzers	18
1 Division Command Post	Wheeled Vehicles	102
	TOW Systems	60
3 Infantry Battalions	Javelin Systems	58
	81mm Mortars	12
1 Artillery Battalion	60mm Mortars	18
1 Engineer Company	Stinger MANPADS	21
1 Air Defense Battery	Engineer Repair Packages	12
1 Combat Support Element	CDS Bundles	54
	Supply Platforms	9

Table 1. Division Ready Brigade Alpha Echelon Composition[16]

Bravo Echelon – Airland Package		
Aviation Task Force - Cavalry Troop - Attack Company - Assault Company	Troops	680
	Wheeled Vehicles	227
	UH-60 Blackhawk Helicopters	12
Armor/Mechanized Team - Tank Platoon - Mechanized Infantry Platoon	OH-58D Kiowa Helicopters	16
	M1A1 Abrams Tanks	4
	M2 Bradley Fighting Vehicles	4
Tailored Support Package	M113 Armored Personnel Carriers	2
Remainder of SBA Units	Avenger Air Defense Systems	12
	Engineer Repair Packages	12
	Supply Platforms	41

Table 2. Division Ready Brigade Bravo Echelon Composition[17]

Type of Delivery	Number of C-17s
Equipment Airdrop (Alpha Echelon)	
- Dual Row Airdrop	21
- Standard Airdrop	7
Personnel Airdrop (Alpha Echelon)	
- Personnel	24
- CDS Platforms	1
Airland (Bravo Echelon)	46
Total Aircraft	99

Table 3. C-17 Aircraft Required for SBA[18]

SBA is an airdrop and airland delivery of a DRB. The airdrop package is referred to as alpha echelon and the airland package is referred to as bravo echelon. Although the DRB is tailorable, there is a planning standard, which is described in Tables 1 and 2. The number of C-17s required to deliver both echelons is listed in Table 3.

As shown in Tables 1, 2, and 3, executing a strategic brigade airdrop is a mammoth undertaking. Although this discussion does not include force structure or planning considerations it is worth mentioning how massive such an operation would actually be. The total aircraft requirement of 99 C-17s represents nearly five-sixths of the entire fleet as of September 2004. Given the assumption that SBA is conducted from an intercontinental distance, few, if any, of the aircraft and crews will be able to conduct multiple sorties. The scope of the operation is magnified when taking air refueling into account. Depending on where the SBA is conducted and how many air refuelings are needed for each C-17 it is possible for the tanker requirement to reach approximately 200 airframes.[19] Even when all 180 C-17 aircraft have been procured, this force comprises a significant portion of AMC's airlift and air refueling capability.

Resolving SBA Issues

Pass Time

Notional theory and good intentions aside, executing an SBA within the 1997 SBA Joint IPT requirements has been a difficult, expensive, and somewhat elusive proposition. The central reason for the difficulty in translating paper-based requirements into actual capability has been the C-17's inability to meet the 30-minute drop zone pass-time requirement. There are several different reasons why the alpha echelon of C-17s has exceeded the 30-minute pass time.

C-17 Personnel Airdrop Geometry

During the mid-1990s, personnel airdrop testing of the C-17 at Edwards Air Force Base revealed an occasional tendency for the parachutes of jumpers (exiting both the left and right paratroop doors) to come into contact as the chutes deployed downstream of the aircraft. Rare as it was, AMC, the C-17 System Program Office (SPO), and the Army decided that such interactions were not safe and initiated a program to eliminate the problem. In 1996 engineers developed a solution that consisted of modifying the paratroop doors, raising the deck angle of the aircraft during airdrop, and using 20-foot static lines to initiate parachute deployment (as opposed to standard 15-foot static lines). Testing then commenced for formation personnel airdrop.

Remedying the chute collision problem resulted in another problem. During evaluations of formation personnel airdrop, parachutists from following aircraft were observed being jostled about excessively after exiting the aircraft. Analysis revealed that the jostling was caused by excessive wake turbulence from the proceeding aircraft. High-wing, high-drag, powered-lift design characteristics that enabled the C-17 to perform its tactical airland and airdrop missions at large gross weights caused the C-17 to generate a significant amount of wake turbulence and wingtip vortices. When the deck angle was raised during personnel airdrop to alleviate chute interactions, it exacerbated the extent of wake turbulence and vortices.

To rectify this new problem, the program office and AMC initiated an extensive modeling and aircraft-testing program. After months of testing, a workable solution was achieved by altering the geometry of personnel airdrop formations. Standard C-17 formation airdrop of personnel and equipment had been similar to that of the C-141 and C-130—aircraft flew in three-ship elements with 12,000 feet of separation between the lead aircraft of each element. The number two and three aircraft flew to the right and left respectively of the element leader at a spacing of either wingtip-to-wingtip separation (visual conditions) or 500 feet (instrument conditions). The new personnel geometry required 40,000 feet between elements and both wingmen flew on the same side of the element lead (which side depended on wind drift) at a spacing of 650 feet and 1,500 feet respectively.

The consequence of the exceedingly large spacing between elements, magnified over the entire length of a C-17 SBA airdrop formation, resulted in a pass time of 51 minutes. As a result, AMC, the C-17 SPO, and the Army initiated a comprehensive three-program effort to reduce the pass time. The first program involved more modeling and formation geometry testing that resulted in a new procedure of 32,000 feet spacing between elements. This reduced the pass time by 5 minutes to 46 minutes. The program office then analyzed reducing the element spacing to 27,000 feet, but the interaction rate exceeded an acceptable margin and the effort was terminated.[20] The other two programs are Dual-Row Airdrop System (DRAS) and station-keeping equipment (SKE) upgrades.

DRAS

The DRAS is a process by which C-17 cargo compartment logistics rails are used to airdrop equipment platforms. A C-17 cargo floor has two types of rail systems built into it—Aerial Delivery System (ADS) rails and logistics rails. The ADS rails are a pair of centerline rails designed exclusively to airdrop heavy equipment platforms along the aircraft centerline. Logistics rails are two pairs of rails used to load standard 463–L pallets side-by-side along the length of the cargo compartment.

In 1997, based upon a company loadmaster's idea, Boeing made a proposal to use the logistics rails for airdropping heavy equipment platforms.[21] By using both sets of logistics rails to airdrop platforms this would enable the jets to airdrop more platforms per plane, decrease the total number of aircraft required for SBA, and reduce the airdrop pass time. The SPO and AMC agreed and authorized testing in 1997.

Testing proved successful; however, DRAS raised several difficult and expensive deficiencies. One issue was the logistics rail locks were not designed for the load forces the ADS locks experience during airdrop, which necessitated alternate drop procedures. Platforms that are dropped via standard procedures exit the aircraft when the extraction chutes exert enough force to overcome predetermined values on each of the variable lock settings on the ADS rails. The logistics rails do not have locks with variable resistance settings. As a result, the drop procedures were altered for DRAS by retracting the locks prior to a DRAS airdrop. Sometimes DRAS platforms shifted slightly during flight due to turbulence, deck angle changes, or pilot maneuvering and the platforms applied pressure to the logistics locks and caused one or more locks to bind when the time came to retract them. Such binding occasionally damaged the locks. A second deficiency was the mechanisms for releasing the parachutes and extracting the loads using the ADS rails could not completely support the extraction of two rows of platforms. Instead of extracting DRAS loads through a drogue chute process, as is the case with standard equipment loads, they exited the plane using a gravity-release process flown at a different deck angle. The deck angle change induced a third set of problems involving center of gravity issues that affected how the platforms exiting the aircraft caused interactions during deployment, and complicated the rigging process of DRAS platforms.[22] A fourth problem was that 463-L pallets were not designed for airdrop. They are smaller than standard airdrop pallets and not as durable.

Faced with a *must do* situation, the Air Force and Army set about resolving the DRAS issues as best they could. New DRAS air review procedures were developed and new contracts let to procure new platforms. Modifying the logistics rail locks, however, proved to be too expensive and AMC has not been able to acquire the funds to modify the fleet. Using procedures for the current aircraft capabilities, DRAS reduces SBA pass time by 6 minutes, lowering the total pass time to 40 minutes.[23]

SKE Follow-On

C-17s utilize SKE to maintain formation position and execute airdrops during instrument meteorological conditions. Formation aircraft do not have to see each other—aircraft positions are displayed electronically on screens in the cockpit. One aircraft serves as the *master* and the other aircraft electronically synchronizes their internal clocks off of it, providing accurate presentations on all aircraft. A limitation of SKE is that aircraft must be within 10 miles of the master in order to receive acceptable signals. Another limitation is there can only be one master per formation. Aircraft greater than 10 miles from the master must operate on a different SKE frequency (of which there are four) and the SKE presentations are only capable of displaying aircraft using the same frequency. A large formation can tactically work around the frequency limitation by flying separate, smaller formations but the formations require separation for safety sake that greatly lengthens the overall formation. A final limitation is that formations using the same SKE frequency must be at least 80 nautical miles from each other.

The central factor for the difficulty in translating paper-based requirements into actual capability has been the C-17's inability to meet the 30-minute drop zone pass-time requirement.

Remembering SBA consists of 53 aircraft, which equates to a formation length of roughly 90 miles, C-17 SKE hindered executing SBA. Air Mobility Command initiated an acquisition program to procure a new, more capable SKE system which it named SKE Follow-On (SKE-FO). Completely digital in nature and capable of managing and displaying up to 100 aircraft, SKE-FO eliminated SKE's shortcomings. Most importantly, SKE-FO closed the formation and reduced pass time by 14 minutes, bringing the overall pass time down to an acceptable 26 minutes.[24]

SKE-FO was scheduled for a completion date of mid-2005 but the contractor encountered technical difficulties that forced AMC to cancel the contract in late 2003. AMC and the SPO responded with a short- and long-term solution. The short-term solution is a software modification to current equipment, known as Traffic Alert and Collision Avoidance System (TCAS) overlay. TCAS overlay solves certain all-weather issues associated with traditional SKE, but it does not provide any capability to condense formations and therefore does not shorten the pass time. The long-term solution is called Formation Flight System (FFS) and is tentatively planned for a production cut-in of aircraft number P-153 in July 2006. Full fleet modification will occur in 2013.[25] FFS will solve all SKE limitations and reduce pass time by 14 minutes.

Army Transformation and Modularity

Transformation – The Concept

During the late 1990s, the Army embarked upon a long-term plan to reorganize and equip its forces to more capably meet the nation's security needs of today, for the next 20 years, and beyond. The Army Chief of Staff at the time, General Eric K. Shinseki, launched this sweeping program in October 1999 with the following words.

> To adjust the condition of the Army to better meet the requirements of the next century, we articulate this vision: Soldiers on point for the nation transforming this, the most respected army in the world, into a strategically responsible force that is dominant across the full spectrum of operations. With that overarching goal to frame us, the Army will undergo a major transformation….[26]

Every aspect of the Army—personnel, organization, equipment, strategy, and operations—is enveloped within the transformation construct. Seven goals are enumerated to guide the efforts of organizations and individuals alike. Transformation is to make the Army more *responsive, deployable, agile, versatile, lethal, survivable, and sustainable.*[27] Transformation comprises three capabilities-based phases. *Legacy forces* are the heavy armored and mechanized forces that constitute the Army's current primary combat power and will do so for the near future. The *interim forces* are units modified in structure and enhanced with new, available technologies to make them more deployable than heavy units and better armed and protected than the lighter airborne and air assault units. Not all forces would necessarily transition to this stage. Some interim forces will function as technology and feasibility demonstrators for forces that will comprise the third phase of forces. The third phase was initially entitled the *Objective Force* and constituted "the art of the possible: what can be done to equip, organize, and train units to assimilate the best aspects of the heavy, light, and interim forces."[28] In late 2003, the new Chief of Staff, General Peter J. Schoomaker, renamed this phase *Future Force* to reflect a programmatic change in emphasis that is more process-oriented and aimed at "fielding future capabilities as soon as they are available."[29]

A core element of transformation is the institutionalization of brigades in place of divisions as the fundamental combat unit of the Army. Given the immense size of a division (typically around 15,000 personnel) and the dynamic nature of the strategic environment America now faces, divisions are not readily transportable and employable in contingency operations. The primary drawbacks of divisions are as follows.

- They are optimized for major land campaigns against similarly organized forces.
- They are large, fixed organizations with interconnected parts.
- They require extensive reorganization to create force packages.
- They limit the combatant commander's ability to mix and match packaged capabilities for multiple missions.
- They possess limited joint capabilities.[30]

Brigades are more inherently capable of attaining what General Schoomaker envisions for the Army, a "more relevant and ready campaign-quality Army with a joint and expeditionary mindset."[31] Brigades are strategically flexible, adaptive, sustainable, lethal, and can be the antithesis of the division shortcomings identified. The brigades of today are not optimally structured or equipped to maximize these attributes so the Army is focusing on transforming the various brigade types. The overarching concept that governs the transformation of brigades is modularity.

The Modular Army

At present, brigades employ via unit structures known as brigade combat teams (BCT). A BCT is formed by augmenting a brigade with functional elements from the division such as artillery. Commanders form BCTs to accomplish a specific mission. To do that, they employ force tailoring to build the BCT. Force tailoring is the process of selecting units of particular capabilities to accomplish a specific mission. This requirement to reorganize and force tailor reflects the conditions that brigades are not self-contained units nor are they capability-based, which limits their flexibility and immediate deployability. To provide combatant commanders with better capable units for rapid employment, standing combined-arms brigades are required. The Army is moving in this direction by creating units of employment (UE) and modular BCTs (also known as units of action).

A UE is a force of indeterminate, but large, size brought about to confront a contingency and is composed of modular BCTs. There are actually two UE organizations—UEx and UEy. The UEx is "the principle war fighting headquarters of the Army, exercising operational control over brigades employed in tactical engagements," and the UEy, which focuses "primarily on the Army Component responsibilities, supporting the entire theater and the operational forces … as required by the combatant commander."[32] The new building block of the Army, a modular BCT, is composed of modular battalions and companies that are "self-contained organizations that can plug into and unplug from unit formations with minimal augmentation or reorganization."[33] Force tailored for mission purposes, modular BCTs are self-contained organizations that are more flexible, responsive, and deployable than traditional BCTs.

The new building block of the Army, a modular BCT, is composed of modular battalions and companies that are self-contained organizations that can plug into and unplug from unit formations.

The Army's primary tactical unit will be the combined arms maneuver BCT. There are three types of maneuver BCTs: heavy, infantry, and Stryker. Other modular brigades will support the maneuver BCTs and serve UEx functions. By 2012, the Army plans to field a fourth type of BCT composed of future combat systems units.[34]

Of crucial importance to the concept of a modular Army is deployability. Units are reorganizing and equipment is being designed that will be capable of "operational maneuver from strategic distances," which is defined as the rapid projection of scalable, modular, and force tailored combined arms that are capable of operations immediately upon arrival.[35] Pursuant to this philosophy, the Army requires that brigades be capable of deploying worldwide in 96 hours and UEs in 120 hours. These ambitious requirements have reverberated throughout the Army as units at all levels investigate, plan, and structure themselves to meet them.

Modularity and Systems Development

Unit deployability in the modular Army encompasses not just the structure or size of units but also unit equipment composition. Central to transformation and modularity are robust new weapon systems optimally designed for functionality and deployability. Several of these programs will likely affect SBA operations. One program is currently being fielded and the other two are under development.

Stryker IAV. The Stryker Interim Armored Vehicle (IAV) is a family of vehicles the Army is procuring from General Dynamics Land Systems under the interim forces construct of transformation. Departing from the Army's tracked-vehicle tradition, the Stryker is an eight-wheeled, 19-ton armored vehicle that is both strategically (C-5/C-17) and operationally deployable (C-130). There are two Stryker variants, the infantry carrier vehicle, of which there are eight configurations, and the Mobile Gun System. The vehicle is capable of speeds in excess of 60 miles per hour and its range exceeds 300 miles.[36] A C-17 aircraft can airlift four Strykers (airland mission) or carry and airdrop two vehicles.

The Army is on contract for 2,112 Strykers that are being fielded to six Stryker brigade combat teams (SBCT).[37] Strykers present combatant commanders a vehicle that is very mobile, armored, combat ready, and more easily deployed than Abrams tanks or Bradley fighting vehicles. On August 13, 2004, a Stryker was successfully airdropped by a C-17 at Edwards Air Force Base. It was the first of several test airdrops planned to evaluate its suitability for use with airborne forces. Although programmed for long-term use by Army units, the Stryker is an interim program that leverages current technology to satisfy current needs.

FCS Vehicle. The Future Combat System (FCS) vehicle will be the primary weapon and infantry-carrying vehicle of the Future Forces. The vehicle and its eight variants encompass a portion of 18 hardware systems collectively known as the Future Combat System. Still largely on the drawing board, FCS will incorporate many advanced technologies in multiple configurations that make use of a common vehicle platform. Variants of the FCS vehicle roles include mounted combat, command and control, infantry carrier, reconnaissance and surveillance, cannon, mortar, maintenance and recovery, and medical treatment. The vehicle will also incorporate network-centric capabilities for reception and dispersal of information.

Deployability is critical to the FCS vehicle design. The vehicle must meet the following requirements.

- Total weight is limited to 20 tons.
- Be capable of airlift by a C-130.
- Be 70 percent lighter and 50 percent smaller than an Abrams tank. (An Abrams tank weighs 70 tons.)[38]

An airdrop requirement has not been set for the FCS, however since it is approximately the same size as a Stryker, that capability is assumed for this discussion. The Army is striving to design, build, test, and field the FCS by 2008 and equip a majority of intended units by 2013.

PEGASYS and JPADS. The Army and Air Force are keenly interested in developing precision airdrop capability, particularly from high altitude. Currently, equipment airdrop is accomplished by C-17s and C-130s using unguided *dumb* chutes normally at an altitude of 1,000 feet above the ground or less, at airspeeds close to landing speed. These factors make the aircraft extremely vulnerable to ground fire and surface-to-air missiles. Dropping at higher altitudes to avoid threats decreases the accuracy of the airdrops. It is not uncommon for airdrops conducted at altitudes greater than 20,000 feet mean sea level (MSL) to result in touch downs a mile or more from the planned point of impact.

The Army initiated a program to field a *smart* airdrop system known as the Precision Extended Glide Airdrop System (PEGASYS) to negate the disadvantages of standard airdrop capabilities. PEGASYS is a family of four Global Positioning System-guided, autonomous, precision high-altitude airdrop systems. The system capabilities are as follows.

- PEGASYS-XL. Cargo from 200 to 2,200 pounds
- PEGASYS-L. Cargo from 2,201 to 10,000 pounds
- PEGASYS-M. Cargo from 10,001 to 30,000 pounds
- PEGASYS-H. Cargo up to 42,000 pounds

The systems are releasable at altitudes up to 25,000 feet MSL with a drop accuracy of 25 to 300 meters, depending on the drop altitude. Each of the PEGASYS systems will be linked to the Combat Track II satellite system, which will allow for in-flight changes of the release point.[39]

In 2003, the Army's PEGASYS-L program teamed with AMC to form a program titled the Joint Precision Airdrop System (JPADS). The Joint Requirements Oversight Council recognized the importance of the program by ranking JPADS as its second highest priority for fiscal year 2004 technology demonstrations. JPADS will be *payload independent*, meaning it will use a platform that can accommodate anything that can fit on the platform. A PEGASYS-M variant will be capable of handling the Army's Heavy Expanded Mobility Tactical Truck Load Handling System and Future Tactical Truck System vehicles.[40]

Transformation, Modularity, and Their Effect on SBA: Determining a Reasonable Approach

The effects of Army transformation and modularization on SBA are still largely unknown. Planners on the 18th Airborne Corps and the 82d Airborne Division staffs have worked various elements of both programs. Members of the corps G-3 (operations and plans) staff indicate that progress has been steady but many issues remain to be worked.[41] Planning to this point can be characterized in three ways. First, both units have been subject to a high wartime operations tempo—personnel deployments have constrained planning efforts. Second, many aspects of the two programs remain in flux. Decisions on organizational issues are further along than weapon system considerations. The 82[d] is already programmed to transition from a three-brigade to a four-brigade structure. The FCS vehicle and JPADS/PEGASYS programs, on the other hand, are not close to production and this impedes decision making. Third, since the programs are so new, nearly all planning remains at the classified level.

This article suggests two approaches for analyzing how transformation and modularity may affect SBA. The first examines the issue from an Army perspective—*What are general actions the Army could take that affect SBA?* Since there are many potential permutations and combinations of hardware and organizational structure, the Army could implement general courses of action. Qualitative considerations are discussed as opposed to quantitative guesses with too many unknown variables. The second presents a proactive Air Force perspective—*What can Air Mobility Command do to optimize SBA for the Army?* This method assumes that forewarned is forearmed. That is, participating in the decision-making process that involves a significant portion of AMC assets is better than reacting to Army decisions after they have been made.

Army Actions Affecting SBA

There are four principal ways transformation and modularity can affect SBA—Improve unit restructuring; field the Stryker, FCS vehicle, and JPADS/PEGASYS. None of these are mutually exclusive of each other. In fact, it is not a question of whether any of them will be incorporated into SBA, but when they will and to what extent. In the following discussion only the predominant positive or negative factors are examined.

Unit Restructuring. Deployability, flexibility, and independence are key characteristics that govern the reorganization and restructuring of Army units. Although the Army is due to increase in overall size during the next few years by 30,000 or more personnel, Army planning is for more efficient and effective *smalle*r units.[42] The four-brigade structure that the 82[d] is in the process of transitioning to maintains the division's current overall manning strength.[43] However, reducing the brigade size may decrease the number of aircraft required for either or both echelons.

It should be noted, however, some individuals caution that modularizing units may actually increase the size of the subunits or the parent unit because of the economies lost by having certain support functions pooled at the parent-unit level.[44] Spreading a function across battalions within a brigade or across brigades within a division may result in more total personnel performing that function than originally was the case. Similarly, modifying units by fielding smaller or lighter weapon systems may entice commanders to want more of the new system. All weapon systems have a logistical tail associated with them, so placing more of them within a unit may enlarge the unit's logistical footprint. Because a C-17 can carry three or four Strykers at a time as opposed to just one Abrams tank does not mean commanders will need to or should do so.

Stryker. There are five major options for incorporating the Stryker into the SBA. These options are not mutually exclusive.

Option 1 – Replace Alpha Echelon Vehicles. Replacing vehicles to be airdropped on a one-to-one basis with any Stryker variant will increase the number of C-17s required. Strykers are twice the length and wider than the average vehicle that is airdropped. Most alpha echelon vehicles are capable of airdrop via DRAS procedures, however, Strykers are not. Thus C-17 requirements would increase. If each Stryker added replaced more than one vehicle because of its greater utility, then it would be possible to maintain or reduce the number of C-17s required.

Option 2 – Add to Alpha Echelon. Adding Strykers to the standard airdrop package without decreasing the number of other vehicles airdropped will increase the number of C-17s required at up to a one-for-two rate. A C-17 is capable of dropping two Strykers on a single pass, but doing so requires the aircraft's maximum airdrop capability. No other platforms can be dropped from the aircraft.

Option 3 – Replace Wheeled Bravo Echelon Vehicles. This option is similar to Option 1 but with less negative impact. Airlanding any type of cargo permits more efficient use of the cargo compartment because fewer rigging and restraining devices are required than for airdropping equipment. The ratio of wheeled vehicles removed per Stryker is greater than it is for Option 1.

Option 4 – Add to Bravo Echelon. C-17s are capable of carrying four Strykers per aircraft. The number of C-17s required is therefore a one-to-three Strykers carried ratio.

Option 5 – Replace Tracked Bravo Echelon Vehicles. A C-17 is capable of carrying four Strykers, two Bradley infantry fighting vehicles, or one Abrams tank. Depending on which and how many vehicles are replaced, it is possible to reduce the number of bravo echelon C-17s, especially with a one-to-one replacement. Conversely, if the Army desires to retain the same number of C-17s, more Strykers can be carried. However, logistical and personnel support would have to be taken into account.

FCS Vehicle. The FCS affords the Army opportunities similar to those of the Stryker since the two vehicles will be approximately the same size and weight. Changes to the airland and airdrop components of SBA will depend on which vehicles or pieces of equipment the FCS replaces. There is the potential to reduce the number of C-17s if the Army replaces equipment at roughly a one-to-one ratio. If the FCS proves to be a quantitative leap forward in capability over the current wheeled, tracked, or towed equipment, there is the possibility for a greater ratio of legacy equipment replaced, which would also serve to reduce the number of aircraft required.

JPADS/PEGASYS. These two systems may have more of a qualitative than quantitative impact on SBA depending on how they are actually fielded. Their precision nature will facilitate the post-drop assembly of airborne forces on the ground—soldiers will not have to spend as much time searching for their designated equipment. The payload-independent functionality of JPADS and PEGASYS-M may influence the number of C-17s required if they allow for higher density airdrops. Higher density airdrop means the platform or container used can hold more equipment or cargo. If the systems can airdrop more equipment, fewer C-17s may be required unless the Army decides to make use of the additional volume by adding more equipment to the drop package.

What Can AMC Do to Optimize SBA for the Army?

Air Mobility Command is a major stakeholder in transformation and modularity initiatives. Although AMC does not always have a vote in Army decision making, it does have opportunities to facilitate and optimize planned initiatives. There are four ways in which AMC can specifically optimize SBA for the Army.

- **FFS.** The unfortunate cancellation of the C-17 SKE-FO program imposes a 3-year delay in AMC's ability to meet the 30-minute pass time requirement for SBA. The 3-year slip should obligate AMC to advocate Formation Flight System (FFS) as a priority program and be willing to fund it accordingly. Both the C-17 SPO and AMC must carefully monitor the program to prevent setbacks and any further delays.
- **JPADS.** Precision airdrop capability benefits AMC and all its airdrop customers, not just the Army, during SBA operations. Properly designed and functional JPADS platforms will not only facilitate ground recovery, they will reduce equipment losses due to errant and off-drop zone drops. The *2004 Air Mobility Master Plan* combat delivery and C-17 roadmap both identify precision airdrop systems as a highly desired capability.[45] AMC should fully support the design and testing of JPADS, which is being carried out by the Army Natick Soldier Center (NSC) in Natick, Massachusetts. AMC should also consider providing additional funding to NSC for JPADS. Such action would accelerate the program and serve as a good-faith gesture in light of the pass time delay caused by the cancellation of SKE-FO.
- **Stryker Airdrop.** Now that a C-17 has successfully airdropped a Stryker, the Air Force and Army need to coordinate, fund, and initiate a full developmental testing program followed by full operational testing. Since the first drop was made using estimated ballistic data, actual ballistic data for a drop of 10 G-11C parachutes must be developed and incorporated into AFI 11-231, *Computed Air Release Point Procedures*, and the C-17 mission computer database.[46]
- **SBA-Related Training.** Conducting a complete SBA or even a portion of a brigade airdrop (known as a *brigade slice*) in a training or combat environment is a daunting operation for all involved, from crews to maintenance personnel to ground support personnel. C-17 formation flights and airdrops of more than nine aircraft are only occasionally practiced due to limitations of available crews, aircraft, ground support, and real world operations tempo. As difficult as it may be to schedule, AMC should ensure that the operational C-17 wings perform periodic large formation airdrop flights of 12 or more aircraft. The 18th Airborne Corps and AMC conducted such exercises on nearly a quarterly basis at Pope Air Force Base during *Large Package Weeks* and annual *Big Drop* exercises; however, high wartime operational tempos for Airborne and C-17 units forced the cancellation of some of these events over the past several years.

Ideally, large formation exercises should be conducted in concert with the 82d, dropping personnel and actual SBA cargo and equipment. In particular, AMC should coordinate to drop Stryker and FCS vehicles as they enter the inventory. Outsized, 20-ton vehicles such as these are a challenge for ground personnel to rig and aircrew to load and drop, and are seldom actually airdropped. Providing as many individuals as possible with first-hand experience airdropping Strykers and FCS vehicles will improve the execution of actual SBA operations.

Although the Army is due to increase in overall size during the next few years by 30,000 or more personnel, Army planning is for more efficient and effective smaller units.

Conclusion

Predicting with precision the effects transformation and modularity will have on strategic brigade airdrop is a difficult proposition. The four primary elements of potential influence discussed in this article—unit reorganization, the Stryker, the FCS vehicle, and JPADS/PEGASUS—are independent programs with separate timelines spread out over a number of years. It is possible to make some general assertions using the framework of how Army actions may affect SBA and how the AMC can optimize SBA for the Army. It is also possible, and wise, to compare the two sets of options, and determine what actions can be considered *deal makers* or *deal breakers*.

Modularizing the 82d presents the best opportunity to reduce the size of SBA operations for the Army and AMC. Implementing a four-brigade structure with the existing division decreases the size of each brigade, which should reduce the amount of airlift required to airdrop and airland it. Adopting either or both the Stryker and FCS vehicles for SBA could increase or decrease the size of a notional SBA depending on how it occurs. Replacing alpha or bravo echelon wheeled vehicles with either system could reduce the airlift required depending on the ratio of vehicles replaced. Adding Strykers or FCS vehicles to either echelon will increase echelon size by a handful of C-17s if the swaps are done on a one-for-one basis. Swapping at a different ratio could still result in a net airframe reduction depending on the ratio used. It is too early to judge the influence JPADS or PEGASYS will have on SBA, since the systems are still under development. If the system variants employ some sort of container or platform that will allow a greater density of material to be airdropped, some airframe reductions are possible.

Air Mobility Command has several opportunities to positively influence SBA for the Army. First and foremost AMC, in concert with the C-17 program office, must vigilantly manage the FFS program so as to expeditiously field an effective system. The Air Force is on contract with the Army to meet a 30-minute drop zone pass time. The 3-year slip due to the failure of SKE-

FO accentuates AMC's obligation to achieve this capability. AMC's active support of a successful JPADS program will improve post-drop ground operations and could result in decreasing the size of a notional SBA. The successful test drop of a Stryker appears to prove the viability of doing so in an SBA. If AMC accelerates the test program it can verify that possibility sooner and facilitate ongoing transformation planning. Finally, AMC should maintain an active large formation training program for its C-17 crews. The demands of real-world operations do constrain training opportunities but AMC can provide temporary relief for periodic exercises.

Deal Makers and Deal Breakers.

The Army and AMC have a number of courses of action by which they can influence SBA. Since these options are different in terms of viability, cost, timing, and impact, certain courses of action can be considered *deal makers* or *deal breakers*—the bottom line actions that will most positively and negatively affect SBA. There are two deal makers, unit restructuring and FFS, and two deal breakers, FFS and FCS.

Unit restructuring presents an opportunity to condense SBA and save air mobility resources if 82d brigades are reduced in size. Since AMC is the supporting command, it is not in a position to actively pursue or advocate brigade downsizing. The Army does not have to reduce the size of its brigades but there are significant advantages in doing so. The FFS, on the other hand, is a *must do* for AMC which qualifies it as a deal maker and deal breaker. AMC cannot make the 30-minute pass time requirement without replacing the C-17's current SKE system. A sufficiently functional FFS must permit at least a 10-minute reduction in pass time. FFS will be a deal maker if it functions as advertised; it will be a deal breaker if it doesn't function as advertised, or is fielded later than planned because of technological or funding issues.

The FCS poses the potential to be a deal breaker if it is not fielded within or close to the design weight criteria. If technological limitations preclude a 20-ton vehicle, a heavier vehicle could significantly affect SBA. A heavier FCS vehicle may not be capable of being airdropped. The FCS should prove a benefit to SBA if its weight is kept under control and the Army replaces SBA vehicles (wheeled or tracked) vice adding FCS vehicles to the echelons.

The airdrop and airland movement of the 173d Airborne Brigade into Bashur, Iraq in March 2003 proved the Army and the Joint Chiefs of Staff are willing to conduct a strategic brigade airdrop in combat. The comprehensive impact of the Army's transformation and modularity programs on all aspects of Army combat capability does not diminish this desire. In fact, the central thrusts towards improved deployability, mobility, and lethality, leveraged by technology, increased the possibility of future SBA operations. As the Army reinvents itself through transformation and modularity with the support of AMC, both institutions will affect the composition and execution of SBA. With proper coordination and realistic planning the Army and AMC can significantly enhance a vital element of our national military combat capability.

Air Mobility Command is a major stakeholder in transformation and modularity initiatives. Although AMC does not always have a vote in Army decision making, it does have opportunities to facilitate and optimize planned initiatives.

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Concentration and Logistics

To win in battle we must concentrate combat power in time and space. Strategy and tactics are concerned with the questions of what time and what place; these are the ends, not the means. The means of victory is concentration and that process is our focus here. There are only four key factors to think about if we seek success in concentration. This is not a simple task. Although few in number, their impact, dynamics, and interdependencies are hard to grasp. This is a problem as much of perspective as of substance. It concerns the way we think, as much as what we are looking at. The factors are not functions, objects, or even processes. They are best regarded as conditions representing the nature of what we are dealing with in seeking concentration. They are as follows.

Variability - Uncertainty - Synchronicity - Complexity

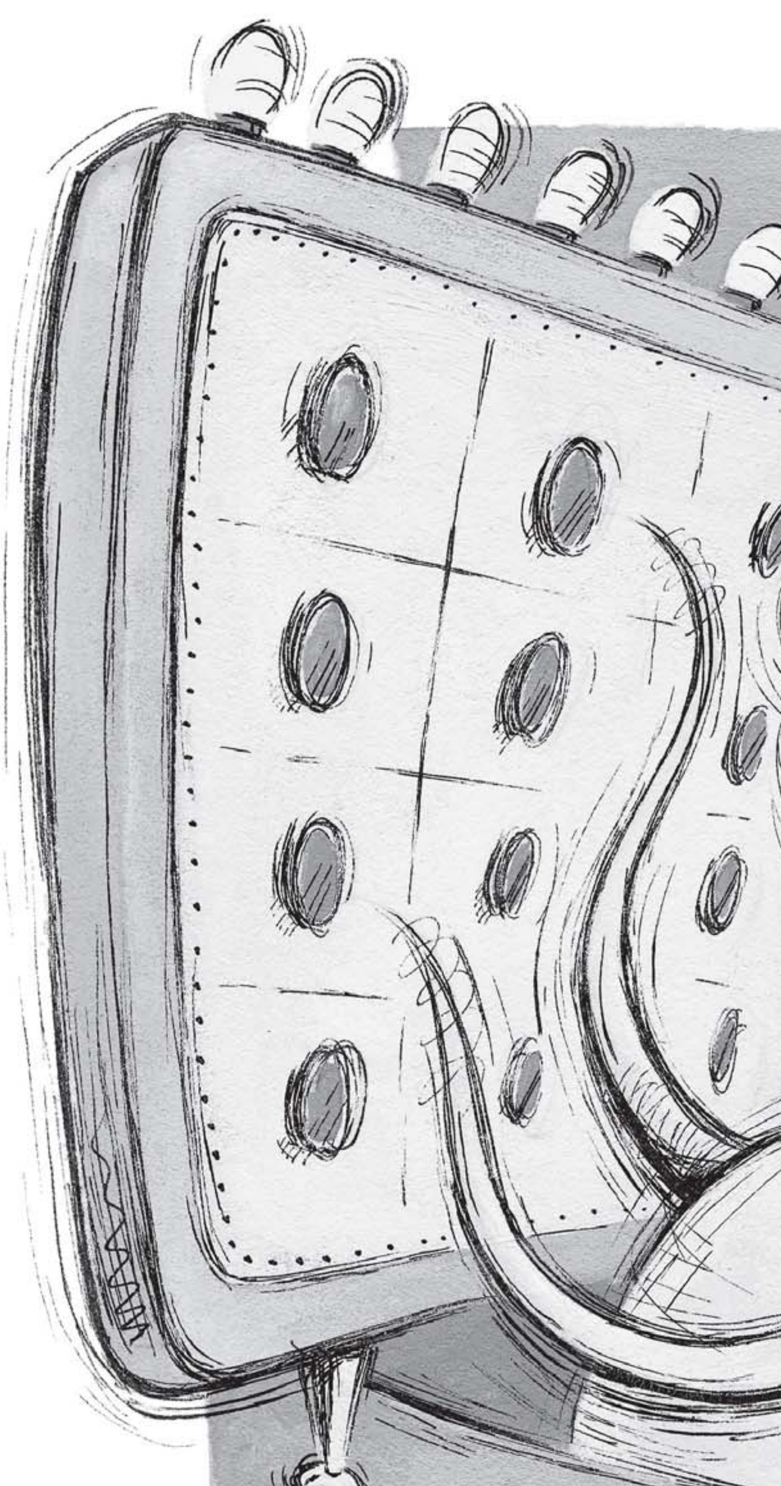
Logistics is not independent. It exists only as one-half of a partnership needed to achieve concentration. Why is understanding this so important? Logistics governs the tempo and power of operations. For us, and for our enemy. We have to think about the partnership of operations and logistics because it is a target. A target for us, and for our enemy. Like any target, we need to fully understand its importance, vulnerabilities and, critical elements to make sure we know what to defend and what to attack. All military commanders, at all levels of command, rely on the success of this partnership. How well they understand it will make a big difference concerning how well it works for them and how well they work for it.

Wing Commander David J. Foster, RAF

Colonel Dennis M. Crimiel, USAF
Colonel Karen W. Currie, USAF

Special Feature

Logistics Enhancing



Introduction

> *The science of logistics concerns integration of strategic, operational, and tactical sustainment efforts while scheduling the mobilization and deployment of units, personnel, equipment, and supplies in support of the employment concept of the geographic combatant commander. The relative combat power that military forces can bring to bear against an enemy is enabled by a nation's capability to plan for, gain access to, and deliver forces and material to the required points of application across the range of military operations.[1]*
>
> ***— Joint Publication 4.0, Doctrine of Logistics Support of Joint Operations, 6 April 2000***

The excerpt above was taken from Joint Publication 4.0. It underscores the very nature of the changing face of logistics support across the Department of Defense (DoD). The point emphasized in Joint Publication 4.0 is that logistics enables our military to bring combat power against our enemy across a full range of military operations. Our military is transforming to meet a very different threat than those that emerged during the Cold War. These emerging threats require our forces to be more flexible, agile, responsible, and lethal. Secretary of Defense Donald Rumsfeld made the point during a Pentagon town hall meeting in March 2003 when he stated:

> We entered the century really arranged to fight big armies, big navies, and big air forces, and not to fight the shadowy terrorists and terrorist networks that operate with the support and assistance of terrorist states. And that's why we are so focused on transforming the department and the armed services. To win the global war on terror, the armed forces simply have to be more flexible, more agile, so that our forces can respond more quickly. [2]

As part of the overall transformation process, the military is jointly moving ahead in transforming its logistics processes as well.

In 2004, the Joint Staff updated its *Focused Logistics Campaign Plan,* which articulates a comprehensive, integrated approach for achieving full spectrum logistics support for the future joint warfighter.[3] The plan is intended to be used at all levels of the Joint Staff, military Services and Agencies as the cornerstone for logistics transformation. The Office of Force Transformation within the Office of the Secretary of Defense (OSD) produced a joint concept for logistics entitled the *Operational Sense and Respond Logistics Concept Plan* (S&RL) which "is a transformational, network-centric, knowledge-driven

Executive Agents

Support to the Joint Warfighter

Article Acronyms

APOD – Aerial Port of Debarkation
APOE – Aerial Port of Embarkation
AFLMA – Air Force Logistics Management Agency
BOS – Base Operating Support
DAAS – Defense Automatic Addressing System
DDOC – Deployable Distribution Operations Center
DLA – Defense Logistics Agency
DFSC – Defense Fuel Supply Center
DFCC – Digitized Force Coordination Cell
DoD – Department of Defense
EA – Executive Agent
GAO – General Accounting Office
ICP – Inventory Control Point
ISR – Intelligence, Surveillance, and Reconnaissance
ITV – In-Transit Visibility
MILSTRIP – Military Standard Requisitioning and Issue Procedures
OEF – Operation Enduring Freedom
OIF – Operation Iraqi Freedom
OSD – Office of the Secretary of Defense
PBA – Performance-Based Agreements
QDR – Quadrennial Defense Review
RFID – Radio Frequency Identification
RMA – Revolution in Military Affairs
SPOD – Sea Port of Debarkation
SPOE – Sea Port of Embarkation
S&RL – Sense and Respond Logistics
USTRANSCOM – United States Transportation Command

concept plan that enables joint effects-based operations and provides precise, agile support."[4] The two initiatives complement one another and provide the overarching guidance and approach DoD will use to transform logistics.

Logistics is a complex business, and while great improvements have been made since the first Gulf War to streamline processes and better respond to warfighter needs, much work remains. Several reports including recent General Accounting Office (GAO) and OSD-sanctioned after-action reports, as well as others on Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) have highlighted the need for the type of transformational changes in logistics noted in the *Focused Logistics Campaign Plan* and the S&RL Initiative. Recurring themes in all of these documents focused upon the continuous need for improvements in areas such as end-to-end distribution, logistics enterprise and integration, and supply-chain management. The *Focused Logistics Campaign Plan* addresses the challenges noted in the reports through transformation in the areas of joint deployment/rapid distribution and agile sustainment. Under agile sustainment, one of the measures now underway to address future warfighter support is to reengineer the executive agent (EA) process. According to the plan, the use of EAs is one means to improve efficiency in the end-to-end distribution process, prevent duplication of effort, reduce waste of scarce resources, and provide a common means for warfighter support for certain commodities.[5]

In a memorandum dated March 2003, the Deputy Under Secretary of Defense for Logistics and Readiness, Diane K. Morales wrote, "Transforming logistics to meet the Future Logistics Enterprise objectives requires that we realign key roles and responsibilities to ensure end-to-end warfighter support, from requirements planning to acquisition through distribution and on to the ultimate customer."[6] She went on to say, "The DoD Component sources of supply whether they are weapon system program managers, commodity executive agents, or traditional Defense Logistics Agency (DLA) or military Service material commands, must assume full responsibility for satisfying warfighter support, regardless of what entities are executing the supply chain."[7] DoD Directive 5101.1, *DoD Executive Agent*, defines a DoD Executive Agent as, "The head of a DoD Component to whom the Secretary of Defense or the Deputy Secretary has assigned specific responsibilities, functions, and authorities to provide defined levels of support for operational missions, administrative, or other designated activities that involve two or more of the DoD components."[8] The use of executive agents presents a real opportunity for DoD to capitalize on improvements in end-to-end distribution, supply-chain management, logistics integration and interoperability for commodities such as fuel, food, medical, and construction barrier materials.

How Did We Get Here

For nearly 30 days after D-Day, the requisition flow out of [3d Infantry Division] dwindled to a trickle. During 3 weeks of intense combat operations, the logistics requirements for this superb division were nearly invisible to the sustaining base because their division's logisticians could not pass their requirements off the battlefield. An expeditionary Army *will not succeed if unit requirements are not visible in real time.*[9]

Lieutenant General C. V. Christianson
Deputy Chief of Staff, USA/G4

Numerous articles and books have been published over the past several years on how to improve logistics support to the warfighter. DoD has made tremendous strides in logistics support during the past 20 years. General Christianson's remarks above highlight some of the difficulties our military faced during OIF and underscores the need for transforming logistics as our military looks to the future. An Air Force Logistics Management Agency (AFLMA) article noted, "The end of the Cold War and the experiences gained from conflicts in Grenada, Panama, and the Persian Gulf essentially brought the era of brute force logistics to a close." [10] Interestingly enough, however, that article was written in March of 1999. In an era where America's military remains the preeminent force in the world, one could ask why transformation is necessary. The *National Security Strategy* published in 2002 greatly clarifies why our military must transform. It states:

> The unparalleled strength of the United States armed forces and their forward presence has maintained the peace in some of the world's most strategically vital regions. However, the threats and enemies we must confront have changed, and so must our forces. A military structured to deter massive Cold War-era armies must be transformed to focus more on how an adversary might fight rather than where and when a fight might occur. We will channel our energies to overcome a host of operational challenges.[11]

OSD and GAO Findings

The OSD-sponsored after-action report (*Objective Assessment of Logistics Operations in Iraqi Freedom*) published in March 2004 used the same term, brute force logistics, in its introduction when describing logistics support in OIF. The OSD report revealed numerous challenges in providing logistics support to the warfighter and noted that in one of the Army's after-action reports logistics was characterized as *brute force logistics*.[12] In both cases the authors were referring to the old practice of using large or massive stockpiles of supplies and equipment to support combat operations. This concept is analogous to a phrase coined by Lieutenant General Gus Pagonis after the Gulf War in which he described logistics support in terms of "moving mountains." [13]

Retired Rear Admiral Andrew A. Giordano wrote,

> The military supply chain's only reason for existence is to deliver support to the warfighter in such a way that combat readiness is both achieved and sustained … how to accomplish that objective is the question, and the answer lies in the reengineering of the military's supply chain's last and weakest line—delivery of support to the warfighter, in the way it is needed. [14]

Another logistician also argues that today's logistics and concepts of support are remnants of the old Cold War structure that was designed with an extensive infrastructure with somewhat predictable requirements.[15] He argues further that this concept of support ultimately resulted in logistics tails characterized by stockpiles of materials at various echelons of support.[16]

After reviewing these thoughts, one could draw the conclusion that not much has changed over the past 20 years. However, that is not the case. The research for this article indicates that all of the Services now recognize the need to change legacy systems and

Article Highlights

Logistics is a complex business, and while great improvements have been made since the first Gulf War to streamline processes and better respond to warfighter needs, much work remains.

This article draws upon the lessons identified from various after-action reports and identifies many of the logistics successes and failures seen during OEF and OIF. Further, it examines the basic tenets of the *Focused Logistics Campaign Plan* concerning distribution, supply-chain management, and logistics interoperability, as well as S&RL concepts. The lessons from OEF and OIF can be tied directly to OSD and Joint Staff logistics transformation efforts, which are being undertaken to address logistics improvement. These efforts will provide the framework for EA initiatives and how they will enhance warfighter support. Finally, the article discusses the merits of the EA initiatives and the potential for success.

push toward more jointness and interoperability in logistics. This article draws upon the reviews of our most recent military operations as a means to identify the weaknesses in Service logistics operations that must be rectified in order to improve support to the joint warfighter.

The OSD report highlighted specific problems with end-to-end distribution and supply-chain management. Figure 1, taken from the OSD report, highlights the various nodes in the DoD distribution process. The chart provides a good illustration of the complexity of the distribution process. It also characterizes how loosely the actual supply chain is integrated should one try to trace the actual path a part would have to travel to move from the source provider to the intended recipient. Why is this important? This complex process is part of what generates the many problems for the Services as noted in their after-action reports in terms of in-transit visibility (ITV), supply-chain management, and distribution.

Referring to the chart, the OSD report specifically states, "each step in the chain is fully capable of executing its functional objective, but end-to-end warfighter support is not the primary objective." Processes at each of the nodes must be designed to be interoperable, and managers within the nodes must have the tools to perform their jobs in the context of an integrated solution.[18] In a sense, all of the supply chains are optimized to support the individual Service requirements. However, one can draw the conclusion that joint or interoperability support is difficult in the current setup because of fragmented or stovepiped logistics information systems. This issue is highlighted in the Services after-action reports as well.

This is an area where using EAs to provide common commodity support has great potential. According to DoD 5101.1, "The DoD EA's authority takes precedence over the authority of other DoD Component officials performing related or collateral joint or multicomponent support responsibilities and functions."[19] Essentially, commodity EA's have the potential to be more effective and efficient in optimizing common item support across the Services than the traditional service stovepipes that are not interoperable,

A GAO audit report released in December 2003 also noted similar logistics problems that occurred during the Gulf War and during OIF. The report specifically noted that the "failure to apply lessons learned from previous operations such as the Gulf War and the operations in Kosovo may have contributed to the logistics support problems encountered during OIF."[20] The GAO report cited four specific areas that led to logistics challenges during OIF.

- Poor asset visibility
- Insufficient and ineffective theater distribution capability

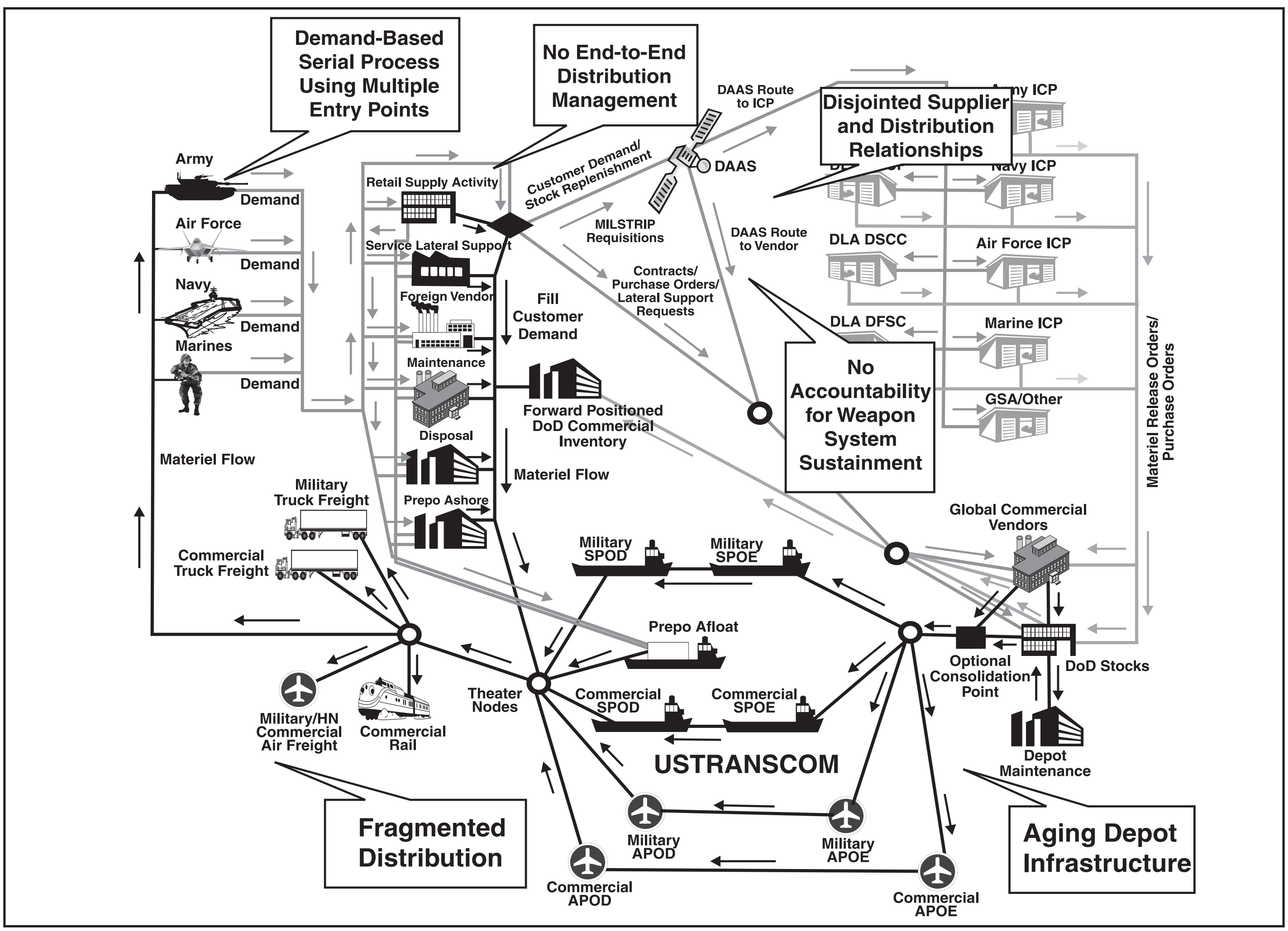


Figure 1. Current DoD Distribution[17]

- Failure to apply lessons learned from previous operations
- Other logistics issues

While citing the logistics challenges, the GAO report also noted the sheer magnitude and volume of supplies shipped to support the war effort. For OIF, DoD obligated $28.1B of which $14.2B was for operating support costs and $4.2B was for transportation costs.[21]

Anthony Cordesman of the Center for Strategic and International Studies also wrote about some of the logistics challenges in OIF in a report entitled, *The Lessons of the Iraqi War: Main Report*, Mr Cordesman writes,

> Advances in logistics allowed the United States to fight halfway around the world with an unparalleled tempo of operations … the ability to refuel aircraft, move fuel and water, maneuver units, maintain and repair equipment in the field, and rearm and sustain was critical to every aspect of the war.[22]

However, Mr Cordesman noted that the operation was not without its share of problems. He observed that,

> US Forces did a great job of improvising and adapting; however, logistics and sustainment need to be better integrated into net-centric warfare and more attention is needed to improve the quality of communications in order to improve the tracking and force management capability at the battalion level and below.[23]

Mr Cordesman's comments were similar to those noted in the OSD report.

One can draw the conclusion that joint or interoperability support is difficult in the current setup because of fragmented or stovepiped logistics information systems.

Military Services and Agency Findings

A Headquarters Air Force, Installations and Logistics-sponsored *Capstone* report published in June 2003 cited numerous issues from OIF that fall into a category of lessons learned which the report characterizes as "enduring potholes." The findings applicable to this article fall into the categories of insufficient ITV, fuels restraints, and inadequate prepositioned assets. The report questioned whether the process used by the Air Force was really intended to provide the type of support outlined in the combatant commander's objectives or was the Air Force intent on providing support through brute force logistics?[24] Again, the words brute force emerge. The report went on to cite "the single largest failure was the failure to provide end-to-end (Port of Embarkation to final destination) ITV." [25]

The Air Force after-action report listed two other areas that were found deficient and needing immediate attention. These two areas, fuels support and base operating support (BOS), have relevance to the EA initiative which will be discussed further in this article. The capstone report indicated that Air Force planners were unaware of the type of host nation support that would be available in the various operation locations required in the operational plan. The planners failed to properly conduct site surveys in these areas and the lack of fuel support could have potentially caused serious mission degradation.[26] Further, the report cited confusion in the area of BOS in locations occupied by joint forces. In some cases, units could not properly perform their assigned missions because of the lack of resources and adequate supplies. The report indicated that most of the problems occurred because of a lack of coordination, a difference in philosophy and definitions, and a fundamental understanding of what Joint BOS really meant among the Services. [27] The report concluded that these logistics issues led to inadequate support and mission degradation at those sites hosted by the Army.[28] Several key recommendations emerged from the Air Force report. The Air Force recommended that "cross functional and interagency planning efforts in regards to fuel need to be reviewed and executive agent responsibilities need to be reviewed by the combatant commander for his area of operations."[29] The Marine Corps faced similar logistics challenges during OIF. Most notably, the Corps faced problems that were related to outdated logistics information systems. The outdated systems caused problems with ITV and distribution. Lieutenant General Kelly, Deputy Commandant, Installations and Logistics, indicated that the Corps needed to replace its old legacy systems that were not responsive enough during the initial phases of OIF.[30] The general indicated the old stovepipe systems and processes caused problems with tracking and distributing parts and supplies as the units moved out from Kuwait.[31] The general also commented that, "the days of putting mountains of Marine Corps logistics on a beach are over and the Corps is now focusing more on seabasing and rapid joint operations."[32]

In the February 2004 issue of the *Defense Transportation Journal*, an article entitled "Army Logistics White Paper—Delivering Material Readiness to the Army," listed four focus areas that the Army will use to change its future logistics systems. The four focus areas are as follows.

- Connect army logisticians
- Modernize theater distribution
- Improve force reception
- Integrate the supply chain [33]

Three of the focus areas correlate directly with the logistics lessons learned from OIF. First, the Army has identified that its legacy logistics information systems are inadequate because of the lack of ITV. The lack of ITV limits the customers' visibility of the items ordered. In many cases, the customer reorders the same items. This results in a redundancy in items ordered and an inefficient use of scarce resources.[34]

The second focus area deals with the problem of theater distribution. The white paper notes the "Army cannot respond rapidly and precisely when support requirements are identified … effective theater sustainment relies solely on the fundamental concepts of distribution-based logistics."[35] The Army is working with its material command and the Defense Logistics Agency to integrate its logistics information systems to enable a more effective logistics distribution system.[36] The fourth focus area deals with the integration of the supply chain. In this effort, the Army is working toward a joint solution to provide the type of end-to-end supply-chain management that is intended to increase speed and deliver focused logistics.[37] A quote noted in the *Torchbearer National Security Report* in April 2004 from Michael Wynne, Deputy Under Secretary of Defense for Acquisition, Technology, and Logistics summed up the problems associated with the military's old way of doing business in the following statement:

> Whether push or pull, our current logistics are reactive. At best, unless we embrace a new paradigm, we will still be depending on the warfighters to tell [the logisticians] what they need, then trying to supply it as fast as [they] can. This amounts to an industrial age vendor struggling to satisfy an information age customer. Reactive logistics—the old logistics—will never be able to keep up with warfare as we know it.[38]

The Army is working diligently to change its logistics support concept from one designed to fight the Cold War to one that is more joint and expeditionary in nature. Major General Terry Juskowiak and Colonel John Wharton wrote in an article for the Army Logistician, "The Army needs to be able to provide the combatant commanders an army that has logistics capabilities designed to support the commander across the spectrum of military operations."[39] They also claim that the Army's logistics capabilities must be joint, flexible, and have a logistics infrastructure that can support simultaneous operations such as deployment, employment, sustainment, and also be integrated to provide a responsive end-to-end distribution system.[40]

The Air Force has identified the need to get more involved in collaborative planning with the Army and wants a better definition concerning executive agent responsibility.

Another author wrote that during OIF, the Army's combat service support units had to perform "miracle after miracle" in the area of distribution just to keep up with combat units.[41] This author also made another more poignant comment by saying that, "the majority of the distribution challenges encountered in OIF were the very same ones faced in Operation Desert Storm 12 years earlier."[42] These comments further underscore the point that in order for the Army to be responsive and agile, it must transform its logistics support structure, which in the past relied on a massive logistics tail to support combat operations. General Juskowiak injects that the Army's transformation strategy must undergo a cultural change and the logistics capabilities of all the Services must be fused with clear lines of command and control across DoD.[43] He further adds that the seams and gaps between the Services and Defense Agencies must be removed.[44]

DLA, a $25B enterprise, supplies more than 90 percent of the US military repair parts and 100 percent of its food, fuel, medical, clothing and textile, construction, and barrier material. DLA played an integral part in providing logistical support to OEF and OIF. According to Mr Allan Banghart, DLA's director of enterprise transformation, the Agency started its transformation processes in the mid 1990s to build and sustain a logistics system that is capable and has agility to ensure warfighter readiness and sustainment.[45] Colonel Leonard Petruccelli, Director of Contingency Plans and Operations, states that "DLA has gotten out of the business of warehousing huge mountains of items but now manages small hills of high demand items."[46]

In planning for OIF, DLA attempted to get out in front of the challenges associated with supporting the military forces over time and distance by working hand-in-hand with the combatant commander's planning staff to build and push sustainment packages prior to the beginning of the campaign.[47] In preparation for the enormous logistics support packages for OIF, OSD allowed DLA $924M of obligation authority to procure and acquire

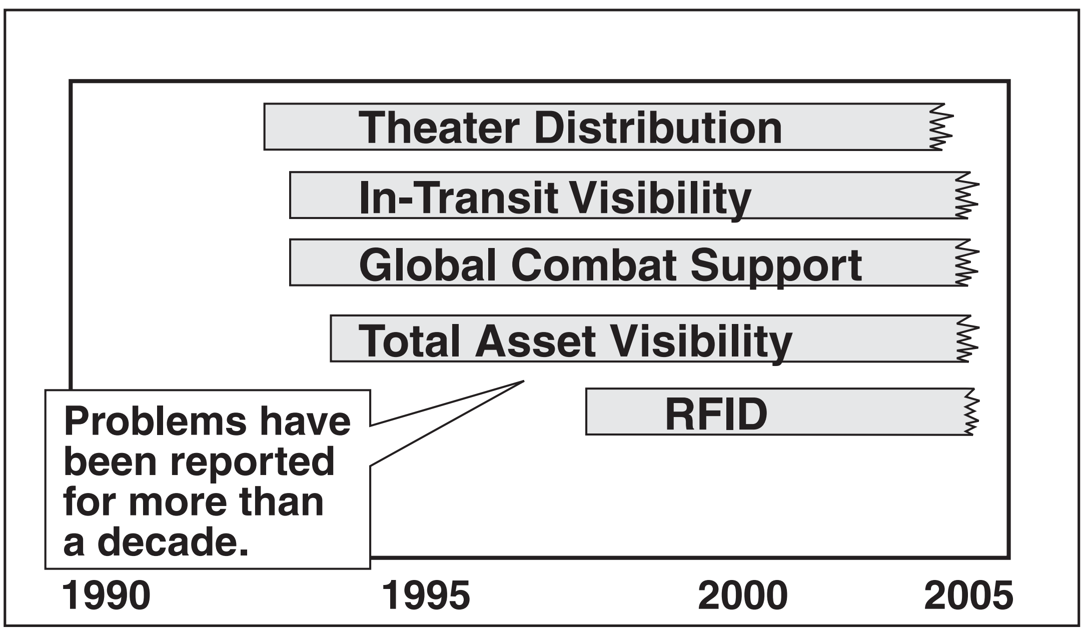


Figure 2. How Many Times Must We Learn the Same Lesson?

numerous types of supplies and equipment that would be in high demand once operations started.[48] DLA's director, Vice Admiral Keith Lippert indicated that "DLA used this effort to validate a new business model that moved away from large warehouses of material to one that now relies on technology and contractors to provide inventory as needed."[49]

DLA's effort to lean forward in planning logistics support with the combatant commander paid big dividends in many cases. However, the OSD report cited numerous examples where the level of support did not have the anticipated impact as expected. More specifically, the OSD report indicated that the planning tool used by DLA, the Integrated Consumable Item Support Model, did an adequate job in determining fuel requirements but was less effective in determining requirements for repair parts and other commodities such as food, medicine, and so forth.[50] In addition, the OSD report indicated that United States Central Command and DLA's effort to forward position huge quantities of construction barrier material had less impact than expected due to the limited visibility of those items by the units that needed them. Consequently, many of the items were needlessly purchased locally.[51] The OSD report also implied that the huge allocation of funds to DLA may have hampered the Services' ability to procure advanced funds for their service-unique requirements.[52]

Despite the tremendous efforts of DLA, the agency also sees the need to continue to transform its processes to better support the warfighter. The problems noted in the OSD report associated with ITV, supply-chain management, end-to-end distribution, and collaborative planning all have implications for DLA. Admiral Lippert indicated that the agency is "reviewing the lessons from OIF to develop its strategies for the future to ensure improvements in the end-to-end process by improving its technological infrastructure and streamlining its business process in an effort to fully integrate the supply chain."[53]

The Need to Apply Lessons Learned and Transform Logistics Practices

The OSD assessment, GAO report, Air Force capstone report, the *Torchbearer National Security Report*, and numerous articles written about the successes and failures of logistics operations during OEF and OIF all point to a couple of central themes. The Services and the combat support agencies must work to transform and integrate their logistics support activities. The *Torchbearer report* sums up the Army's initiatives through the following statement:

> Army logistics has worked to reduce the iron mountains through better business practices and enhanced supply and distribution automation efforts which, to a large degree, have paid off … what has not been realized is the end-to-end visibility over the supply chain and a responsive distribution-based transportation system focused on customer readiness.[54]

The Marine Corps is changing its philosophy by no longer looking to put large logistics footprints on the beach. The Air Force has identified the need to get more involved in collaborative planning with the Army and wants a better definition concerning executive agent responsibility. DLA no longer manages large warehouses but instead stores smaller quantities of high-demand items and relies heavily on technology, contractors, and vendor support in order to be more responsive to warfighter requirements.

The key word spoken and written by all is transformation. Logistics transformation requires that the Services and Agencies learn from past practices and institute reforms to be more responsive and agile to support the warfighter across the full spectrum of the battlefield. The Joint Staff's *Focused Logistics Campaign Plan* seeks to mitigate the myriad of logistics challenges identified in the various after-action plans. In the agile sustainment section of the plan, the Joint Staff has identified the use of EAs as a way to mitigate some of the inefficiencies and problems associated with current Service logistics practices. The plan specifically states: "A robust EA process for coordinating and providing common support to the warfighter can improve efficiency, reduce waste, and minimize duplication of effort among Services and Agencies."[55] Figure 2 poses a question worth considering: How many times must the logistics community continue to learn the same the lesson? This author would argue that the designation of EAs provides DoD a real opportunity to not only learn from previous lessons, but also an opportunity to implement an effective means to enhance warfighter support.

Taken from a briefing delivered by Ms Diane K. Morales in November 2003, Figure 2 illustrates a point addressed earlier. It addresses the fact that many of the very issues that DoD continues to tackle have been prevalent for over a 10-year period. In a speech given to the Conference of Logistics Directors in November 2003, Ms Morales used the chart to emphasize the point that the logistics community has been dealing with these issues since Desert Shield and Desert Storm but it is now time to build upon the current momentum in transformation and work to resolve these issues quickly.[57]

Much of this section of the article was based on the OSD Assessment, which provides a more elaborate and detailed list of findings. Many of the report's findings are not new to the logistics community but the findings illustrate that much work is still required. More specifically, the report cites the following.

- Gaps in the supply chain (supply-chain management) due to Service-unique stovepipes and organization alignments
- Lack of extensive collaborative planning
- Lack of a single controlling element for intratheater movement (end-to-end distribution)
- Unreliable or inoperable logistics communications process (lack of ITV) [58]

All of these findings, along with some lessons previously cited in the past, drive the need to transform DoD's logistics processes. Finally, the OSD report cites the need to change joint doctrine for logistics support of combat operations. Joint Publication 4.0 specifically states, "logistics planners must focus on seamless deployment, distribution, and sustainment in order to properly enable the employment concept of the mission or task."[59] The OSD report cites that joint doctrine for logistics is inconsistent and not directive in nature thereby causing the Services to relearn the same lessons each time they go to war."[60]

What Are We Doing Now

Introducing change in any organization is never an easy process. Many in the logistics community have readily recognized the

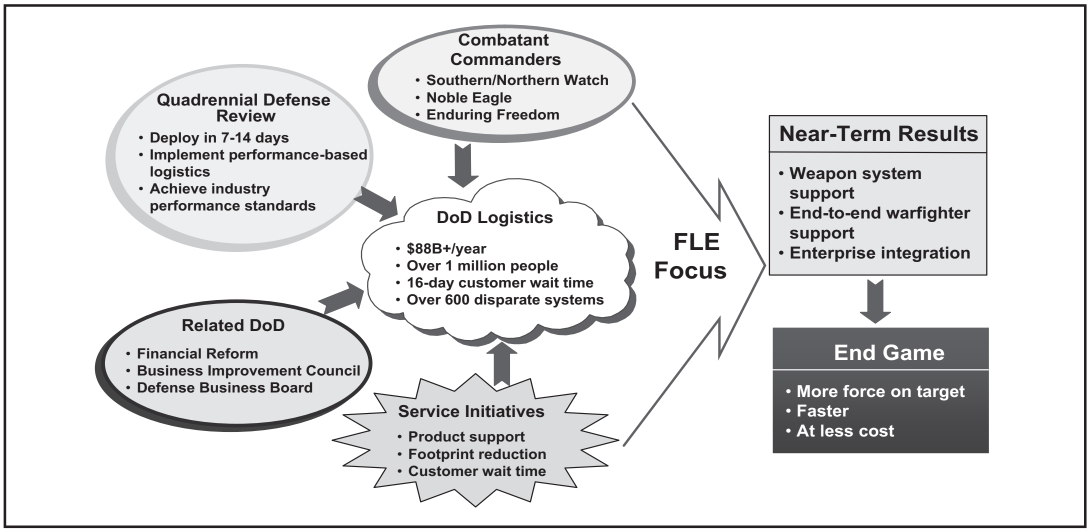


Figure 3. Change Drivers [66]

need to transform current logistics processes and practices to ensure better support to the warfighter. John P. Kotter, a noted author on leadership writes "Transformation requires sacrifice, dedication, and creativity … only leadership can get change to stick quickly by anchoring it in the very culture of an organization."[61] OSD, the Joint Staff, and the military Services and Agencies are all engaged in transformation processes. The Joint Staff's *Focused Logistics Campaign* and OSD's Office of Force Transformation's *Operational Sense and Respond Logistics* concepts provide a backdrop for all of DoD's transformation efforts in logistics.

DoD logistics is complex and enormous. Mr Alan Estevez, Assistant Deputy Under Secretary for Defense (Supply-Chain Integration) described DoD logistics in a briefing on DoD Logistics Transformation in April 2003. Mr Estevez iterates that "DoD logistics employs over one million personnel, engages over 80,000 industrial providers, consumes over $85B a year and is still structured to win a Cold War due to its multi-echelon inventories and maintenance and its large capital-intensive footprint."[62] During OEF and OIF, the Defense Logistics Agency alone provided more than 66 million individual meals ready to eat and over 2.6 billion gallons of petroleum and lubricants.[63] The sheer magnitude of DoD logistics introduces impediments to transformation, but change is necessary in order to support the goals introduced in the *Focused Logistics Campaign Plan*. The campaign plan states "that transformed logistics capabilities must support 1) future joint forces that are fully integrated, expeditionary, networked, decentralized, adaptable, capable of decision superiority, and increasingly lethal, and 2) support future joint operations that are continuous and distributed across the full range of military operations."[64]

Logistics transformation has been underway for a number of years. Paul Needham writes that the "transformation of military doctrine, strategic and operational concepts, and logistics processes began in the aftermath of the first Gulf War when the Joint Staff published *Joint Vision 2010* and later *Joint Vision 2020*."[65] Each Service has adopted new transformation strategies to ensure support to the joint warfighter. Figure 3 provides a good depiction of the many *change drivers* that provide the underpinning for DoD's transformation efforts.

According to Needham, focused logistics is "intended to refocus the Services and the combatant commanders toward reducing forward inventories to a minimal amount and relying instead on consistent resupply."[67] Under Secretary of Defense Morales commented in November 2002 that the *Quadrennial Defense Review* (QDR) provides the "blueprint for DoD to transform our forces to meet the threats of the 21st century by establishing a set of requirements for DoD logistics." [68] The logistics transformation guidance from the QDR is as follows:

> As we contend with the difficult challenges of the war on terrorism, we must proceed on the path of transforming America's defense. Our commitment to the nation will be unwavering and our purpose clear: to provide for the safety and well being of all Americans and to honor America's commitments worldwide. As in generations before, the skill of our armed forces, their devotion to duty, and their willingness to sacrifice are at the core of our nation's strength. We must provide them with the resources and support they need to safeguard peace and security not only for our generation but also for generations to come.[69]

Accordingly, the requirements set by the QDR include the following.

- Project and sustain the force with minimal footprint
- Implement performance-based logistics to compress supply chains
- Improve weapon system readiness, and improve the availability of commodities
- Reduce cycle times to commercial industry standards[70]

One of the outgrowths of the requirements established by the QDR is the mandated use of performance-based agreements (PBA) between DoD entities that are sources of supply and the customers at major command levels. In March 2003, OSD levied a requirement upon these parties to sign collaborative agreements that would employ a customer-focused supply-chain strategy.[71] These PBAs would serve as a baseline for determining the sustainment requirements for the warfighter during execution of operational plans and also serve to codify realistic expectations between the customer and the supplier in terms of levels of support.[72] The use of PBAs is also an attempt to provide end-to-end customer support and puts the onus for providing that support on the supplier to oversee the process from requirements planning to acquisition and onward to distribution to the customer.[73] This OSD guidance applies to program managers, weapons-system managers, [commodity EAs], combat support agencies, and the Services' material commands that are responsible for execution of a supply chain. A key part of the initiative is the requirement for collaboration between the source provider and the customer (warfighter). In addition, the supplier efforts to meet the customer's requirements have associated metrics that have been formally agreed upon.[74]

Paul Needham injects that "logistics transformation is essential to the defense transformation efforts that have been labeled the revolution in military affairs (RMA)."[75] Needham suggests that the operational concepts being introduced by RMA which include joint response strike forces, enhanced information networking, swifter power projection, realigned overseas presence, accelerated deployment, maritime littoral operations and so forth, require a transformed logistics support process and logistics organizational structure.[76] OSD, Joint Staff, and all of the services and support agencies recognize the need to transform.

In the updated *Focused Logistics Campaign Plan*, Vice Admiral Holder, Joint Staff Director of Logistics asserts that the very nature of future joint warfighting will demand improvements in logistics support processes, systems, and organizations in order for the logistics community to effectively deploy and sustain joint forces.[77] The lessons from OIF and OEF identified by OSD and the lessons from previous engagements, along with the change agents discussed earlier, all signify and necessitate the need for DoD logistics to transform. The *Focused Logistics Campaign Plan* sets the overall vision and outlines the strategy and direction for the logistics community to follow. As John P. Kotter noted in his book *Leading Change,* "reengineering, restructuring, and other change programs never work over the long run unless they are guided by visions that appeal to most of the people who have a stake in the enterprise: employees, customers, stockholders, suppliers, communities."[78] Although Kotter talks in business terms, one can easily substitute the American people and Congress as stakeholders, the warfighters as customers, and the logistics community as the suppliers and understand the gist of Kotter's point. DoD logistics transformation efforts have started with a clear vision and all parties in the logistics community are working on different aspects of the plan to shape logistics for the future.

Many in the logistics community have readily recognized the need to transform current logistics processes and practices to ensure better support to the warfighter.

Operational Sense and Respond Logistics

Complementary to the *Focused Logistics Campaign Plan* is the *Operational Sense and Respond Logistics Concept Plan* (S&RL) under development in the OSD, Office of Force Transformation. This concept expands or broadens the current logistics transformation efforts already underway. S&RL conceptually looks to use technology to *sense* customer needs and provide a rapid *response* to the customer demands.[79] According to the concept plan, "the resultant logistics structure created using sense and respond technology is a mosaic of suppliers, services, commodities, facilities, operations, distribution assets, tactics, techniques, procedures, and so forth, that operate in a coherent, coordinated, self-synchronized, dynamically adaptive manner to meet commander's intent."[80]

The concept paper also ties a number of lessons learned from OIF to the need for the type of sense and respond logistics advocated by S&RL. Again, the central themes (end-to-end distribution, total-asset visibility, and supply-chain management) emerge as focus areas that S&RL will be designed to improve. Table 1, taken directly from the S&RL concept document, lists some of the logistics issues from a US Army Rock Drill that will be addressed within the envisioned capabilities of S&RL. In essence, the capabilities being designed in S&RL to address these issues are complimentary to efforts being employed under the *Focused Logistics Campaign Plan*.

Conceptually, S&RL will have the types of technology embedded that will help the logistics community adapt its processes and structures to be more flexible and adaptive to supporting the warfighter across the full spectrum of military operations. Though still in the concept phase, S&RL is being designed with some key enabling concepts that can be directly tied to the EA initiative. The enabling concepts of S&RL fall under six categories: adaptability and speed, effectiveness, flexibility, modularity, integration, and options for military tasks and effects. Figure 4 depicts key and enabling S&RL concepts.

For purposes of this article, three of the enabling concepts (adaptability and speed, effectiveness, and flexibility) have direct applicability to the recurring themes mentioned—end-to-end distribution, total-asset visibility, and supply-chain management. First, S&RL will be designed to achieve adaptability and speed. The enabling concept is that "logistics networks will be designed to self-synchronize through a common environment and set of shared objectives to achieve satisfaction of operational requirements at the point of effect."[83] In other words, the logistics system will be designed to readily respond to changing customer needs by identifying requirements based on usage trends and abnormal demand patterns in real time.[84] This is counter to present day logistics processes that are designed for simple and procedural responses to customer demands.[85] Second, S&RL will be designed to make logistics support more effective by continually monitoring the evolving strategic, operational, and tactical situations and then tailoring logistics support packages to optimize support for the warfighter.[86] Third, S&RL will improve sustainment of the warfighter's requirement by employing a network that is highly flexible and includes a detailed knowledge base for asset visibility.[87] S&RL will be designed to "broaden the logistics resource base and assure visibility of all the elements and components of logistics assets from all potential sources to achieve full spectrum asset visibility."[88]

Memorandum Issue	Analysis	Responsive Capability	
		Number	Capability
Distribution and logistics in the initial phases of OIF were chaotic, inefficient, and generated unacceptable risk to operations.	The primary focus of logistics operations should be achievement, in all phases of operations, of commander's intent, focusing on speed and quality/effectiveness of support versus mass and efficiency.	OIL-2	Synchronize logistics operations with commander's intent, operations functions, and ISR by maintaining and exploiting total situation awareness based on: evolving commander's intent; the strategic, operational, and tactical situation; the operational environment; and force capabilities.
Unclear that better, or even good planning would have made any difference.	Static, history-based planning factors are not adequate: dynamic adaptation of logistics support must be provided.	OIL-3	Anticipate force capability and logistics needs to proactively sustain the force and alter initial conditions.
DLA involvement in theater logistics operations needs to be formalized.	A single perspective of logistics, from point-of-effect to source-of-supply, and focused on achievement of commander's intent, must be developed, and should eliminate process and structure lines associated with hierarchical organizations.	SSPE-5	Permit the direct correlation of logistics resource demand to sustaining base suppliers and manufacturers, connecting point-of-effect to source-of-support, and enabling autonomic logistics.
Joint, multi modal, nodal and functional distribution organizations are necessary.			
Distribution community requires an integrated, vertical view of the supply chain starting with a view of the supported commander's requirements.			
Need to base distribution decision making on operational situational awareness. Move towards distribution metrics that are "effects based" rather than business based.	Commander's intent, including its expression in the form of desired effects, must be the predominant measure and factor in logistics support.	OIL-2	Synchronize logistics operations with commander's intent, operations functions, and ISR by maintaining and exploiting total situation awareness based on: evolving commander's intent; the strategic, operational, and tactical situation; the operational environment; and force capabilities.
		OIL-5	Implement commander's intent, expressed in effects, missions, and tasks, in every aspect of logistics, across the full range of military operations, and for the full set of force capabilities.
Disconnect evident between US Army Combined Arms Support Command and Department of the Army view on configured loads.	A single perspective of logistics, from point-of-effect to source-of-supply must be developed, and should eliminate process and structure lines associated with hierarchical organizations.	ASRL-3	Permit rule-based, adaptable, peer-to-peer, autonomous demand and supply of logistics resources across battle space elements in all organizations, services, and allied, coalition, and treaty organization forces.

Table 1. US Army OIF Logistics Issues (Rock Drill) Versus Capabilities [81]

S&RL is intended to be "implemented as a cross-service, cross-organizational capability that provides end-to-end, point of effect to source of support network of logistics resources and capabilities."[90] The enabling concepts of S&RL will complement the work already underway under the *Focused Logistics Campaign Plan*.

Focused Logistics Campaign Plan

The 2001 QDR provided the impetus for our military to take the necessary steps to transform in order to meet the challenges of a very different threat. The QDR requires the warfighters to shift focus from a threat-based mentality to a focus that now centers on a capabilities-based approach to deter and defeat potential adversaries.[91] The guidance from the QDR and OSD has galvanized efforts to transform our logistics support strategies to support the warfighter in all types of operations regardless of whether the threat is symmetrical or asymmetrical. Two of the major initiatives in the *Focused Logistics Campaign Plan,* joint deployment/rapid distribution and agile sustainment provide the goals and strategies needed to rectify the many logistics challenges noted over the past decade and from recent assessments of OEF and OIF. The recurring logistics challenges were documented previously. The problems with global combat support (supply-chain management), distribution (end-to-end distribution), in-transit visibility, and total-asset visibility have been well documented and debated. The campaign plan lays out a strategy to combat these issues.

Under joint deployment/rapid distribution, one of the basic goals is to improve the distribution process. In an effort to make the distribution process more interoperable in terms of deployment, sustainment, and redeployment the Secretary of Defense named United States Transportation Command (USTRANSCOM) as the DoD process owner for distribution.[92] Why is this important? This designation essentially puts a single entity in charge of the entire strategic distribution process. The idea behind this initiative is to synchronize the deployment and distribution capabilities of the Services and Agencies. After USTRANSCOM gained this designation, it partnered with DLA and the Services to establish a Deployable Distribution Operations Center (DDOC). The DDOC focuses upon providing improved total-asset visibility—in-transit visibility of force flow, sustainment, and retrograde.[93] Major General Dan Mongeon, Director of Logistics Operations, DLA commented,

> The partnership between USTRANSCOM and DLA brings together complimentary capabilities and skills essential to effectively and efficiently support our military services … it has allowed the synchronization of force deployment and the supply chain integration to support combat operations.[94]

The agile sustainment initiative focuses upon material management, prepositioned war reserve stocks, critical commodities, and force structure (combat support). Some of the goals of this initiative include implementing performance-based logistics, integrating the supply chains, reengineering the executive agent process, improving subsistence support, and employing the single fuel concept, to name a few.[95] As discussed earlier, the Service material commands, support Agencies, and the operational communities have already started the process of establishing performance-based agreements based on warfighter requirements.

Reengineering the EA process provides DoD the opportunity to improve efficiency in providing common item support, reduce redundancy and duplication of requirements, and reduce the demands on scarce resources.[96] Transforming DoD logistics is a massive undertaking that will continue to evolve over the years through continual changes in technologies, better information systems, and more thorough integration of Service and Agency capabilities. The transformation process did not just start but is moving forward as a result of several change agents—QDR, Joint Staff and Service Initiatives, and the changing threat environment that has caused our military to shift its focus to be more agile, flexible, and expeditionary in nature. Transforming logistics will require large investments of funds to improve old legacy information systems and stovepiped business processes. However, some transforming initiatives can be realized through changing organization structures, designation of process owners, and utilization of the executive agency process.

Logistics Executive Agents: Short-Term Wins in the Transformation Process

The overall strategy for transforming DoD logistics will employ the use of long- and short-term goals. Short-term goals can be

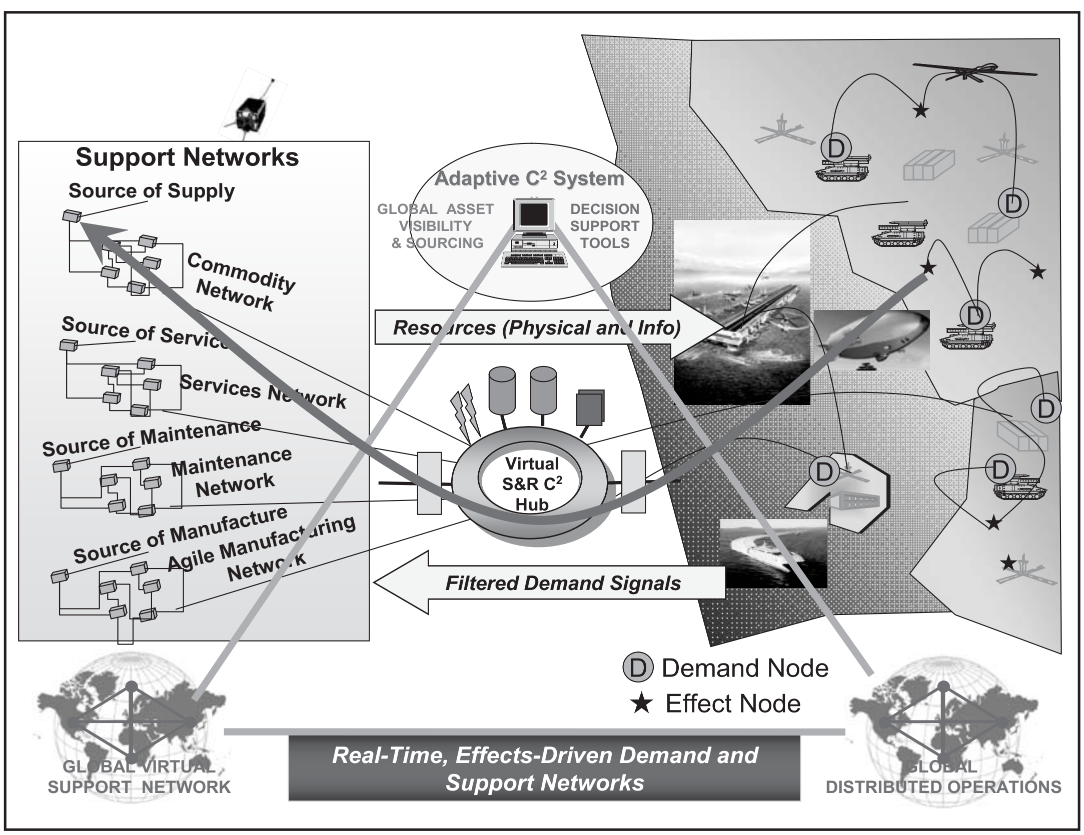


Figure 4. End-to-End Sense and Respond, from Point-of-Effect to Source of Support[82]

realized or implemented in shorter durations than many of the more elaborate goals, which are reliant upon improvements in technology or funds. In fact, many commercial businesses use short-term goals or *quick wins* to build momentum toward achieving the organization's long-term goals. John Kotter writes, "short-term wins are important because they allow an organization to test its vision against concrete data."[97] He also believes that short-term wins allow the organization to adjust its vision and strategies. Without the concentration on short-term wins, developing problem areas may not have been realized until it was too late in the game.[98] The use of executive agents will allow DoD to gain short-term wins in the logistics transformation process.

As explained in the introduction, DoD Directive 5101.1 defines a DoD executive agent as "The head of a DoD component to whom the Secretary of Defense or the Deputy Secretary has assigned specific responsibilities, functions, and authorities to provide defined levels of support for operational missions, administrative, or other designated activities that involve two or more of the DoD components."[99] The directive also states that the designation of EA responsibility is conferred when DoD resources need to be focused on a specific area or areas of responsibility as a means to minimize duplication or redundancy.[100]

Future logistics enterprise, one of the pillars of agile sustainment, includes a number of short-term goals. In a briefing presented to the Supply-Chain World Conference and Exposition held in April 2003, Mr Alan Estevez, Assistant Deputy Under Secretary of Defense (Supply-Chain Integration) identified three near-term goals to transform logistics. These were weapon system support, end-to-end customer support, and enterprise integration.[101] The designation of EAs for common use commodities (food, medicine, fuel, and construction barrier material) across the military services incorporates the objectives of end-to-end customer support. Figure 5 depicts the integrated process embodied in the EA initiative.

OSD published the *Future Logistics Enterprise, The Way Ahead*, in June 2002. The document states the "desired result of the EA initiative is to align EA responsibilities that support the warfighter across the full spectrum of operations including support on an end-to-end basis and rapid response to all deployments, improved crisis and deliberate planning to include EA responsibility, and alignment of the resource (budget, force structure, and so forth) responsibilities associated with the EA."[103]

Applying the EA Concept to Rectify Previous Lessons Learned

The actual designation of commodity EAs provides DoD with an opportunity to address some of the problems cited earlier. The OSD and GAO reports both cite numerous logistics challenges associated with end-to-end distribution, supply-chain management and in-transit visibility. DoD has officially designated DLA as the EA for bulk fuel, subsistence, and medical material. In each of the directives, DoD Directive 5101.8, *DoD Executive Agent for Bulk Petroleum*, DoD Directive 5101.9, *DoD Executive Agent for Medical Material*, and DoD Directive 5101.10, *DoD Executive Agent for Subsistence*, the EA has been charged with the responsibility to manage the supply chain, ensure effective end-to-end distribution, and provide visibility of the various commodities throughout the supply chain. These designations are touted as short-term wins because they provide a potential *fix* to resolve some of the problems associated with only three of the ten classes of supply required to support the warfighter. However, these designations are relative to initiatives that are conceptualized in both the *Focused Logistics Campaign Plan* and S&RL.

The OSD report and other authors cited in this report characterized support to OIF as *brute force logistics*. The general impression gained from these reports and articles is that DoD needs to reengineer its logistics support processes and truly move away from logistics practices that were carried over from the old Cold War support structure. This is an area where EAs can provide a measure of improvement and help to move DoD away from the use of brute force logistics. For example, the EA for bulk petroleum is required "to engage with the DoD components including sharing and leveraging of DoD resources to reduce costs and avoid unnecessary redundancies."[103] The EA for medical material is required to work with the Joint Staff, the Combatant Commanders, and the military Services to consolidate medical material requirements for surge and sustainment, and to execute sourcing and distribution plans to support the warfighter in theater operations.[104] And finally, the DoD components are required to coordinate subsistence requirements with the DoD EA to "assure material availability during peace and war, and prevent duplication of resources."[105] The designation of EAs will therefore allow DoD to reduce costs and duplication of resources, consolidate requirements, and ensure availability of these critical commodities in both peace and war.

Application of the EA initiative has relevance to some of the military Service findings as well. It was noted in the Air Force after-action report that the planners were not aware of what host nation support was available at some locations and that site surveys were not properly conducted. The poor planning could have led to lack of fuel support and degraded mission capability at those locations. In addition, part of the problem cited in this particular case had to do with lack of clarity in which of the Services (Army or Air Force) had responsibility for base operating support. This is an area where the EA for bulk petroleum could have significant impact. The EA is required to "acquire, store, and distribute bulk petroleum to all DoD customers [wherever] and [whenever] it is needed across the full range of operational situations."[106] Further, the EA is required to "coordinate with all DoD components, provide visibility for US Government, allied, coalition, host nation, and commercial bulk petroleum assets."[107] The key words in the directive require the EA to provide bulk fuel whenever and wherever the fuel is needed. In this case, the designation of the EA will alleviate some of the challenges associated with planning for fuels support in joint operations in austere environments.

In the OSD after-action report, four logistics challenges were noted that lend themselves to some resolution by using EAs for common commodities. These four areas addressed gaps in the supply chain due to service-unique stovepipes, limited collaborative planning, lack of a controlling element for end-to-end distribution, and lack of ITV. These four areas are addressed in the three commodity EA designations. More specifically, the EAs are required to collaborate requirements across all DoD components, manage the supply chain, provide visibility of all available assets and ensure end-to-end distribution of assets across a full range of military operations.

Another benefit associated with the designation of EAs is there will be associated metrics and performance indicators that will give the users and suppliers feedback on the level of support being provided. For example, the EA for bulk petroleum is required to establish PBAs with the Components "to set mutually agreed upon expectations."[108] The EA for medical material is required "to assess and report Class VIII supply-chain performance and readiness to include a clear definition of surge and sustainment requirements and material on hand or under contract to meet Class VIII requirements."[109] In the case of the EA for subsistence, the combatant commander is required "to provide timely and accurate forecasts of requirements and feedback to the DoD EA for subsistence regarding the types and quantities of subsistence items to be procured and delivered across the full spectrum of military operations."[110] The responsibilities assigned in the commodity EA directives are fully in line with the requirement for the suppliers and the customers to establish PBA as required by OSD guidance and logistics transformation guidance from the 2002 QDR.

The designation of DLA as the EA for three commodities provides the logistics community with some short-term wins in the transformation process. The EAs for these commodities now provide a single face to the customer and they are also responsible for end-to-end customer support and can eliminate gaps in the supply chain. This designation also requires collaborative planning between the EA and the commodity users, which in the long term, reduces duplication of effort and reduces unnecessary expenditure of critical funds for scarce resources. The designation of these commodity EAs will only address a small portion of the logistics challenges noted in the various OSD, GAO and Service-sponsored reports. However, these designations are one means to support the joint warfighter.

Conclusion

Transformation of DoD logistics is a huge undertaking and has been in progress for a number of years. The logistics community is transforming to ensure it can fully support the warfighter across the full spectrum of military operations. One of DoD's greatest challenges is transforming a military that was designed, structured, and funded to fight a Cold War enemy that no longer exists. Today's threat environment poses a very different enemy than our military was geared to fight. Consequently, the 2001 QDR, the national security strategy of 2002, and guidance from the Secretary of Defense have all established the requirement for transformation of our military forces. These change agents have spurred a series of initiatives intended to provide full spectrum logistics support to the warfighter.[111] The use of EAs for common commodities is one means that is fully in line with the logistics transformation initiatives that will allow the logistics community to improve support to the joint warfighter.

DoD logistics has to adapt to be more agile, expeditionary, and flexible in nature. The Joint Staff's *Focused Logistics Campaign Plan* provides an overarching integrated approach to transforming joint logistics capabilities. OSD's *Operational Sense and Respond Logistics Concept Plan* seeks to exploit new technologies that will allow logisticians to sense the requirements of the warfighter and respond in a more expeditious manner. The military Services have all instituted transformation initiatives as well to improve end-to-end customer support, in-transit visibility, total-asset visibility and theater distribution. However, as mentioned earlier, many of the transformational changes have yet to have the impact intended. After-action reports and assessments from our recent experiences in OEF and OIF indicated that many of the logistics lessons identified from operation Desert Shield and Desert Storm are still plaguing our military today. The recurring themes fall into the categories that are all part of the transformation initiatives underway that DoD is working to resolve.

Transformation is a long-term process that will require huge investments in technology, organizational restructuring and realignments, and improvements in logistics processes and procedures. However, there are some areas that can have immediate impact without massive changes. The designation of executive agents for common use commodities such as fuel, food, medical material, and construction barrier materials is a near-term solution that has merit. The designation of DLA as the EA for these commodities is smart business. DLA already procures and manages the supply chain for these commodities. In essence, this designation will reduce duplication of effort on the part of the Services, improve the procurement process through consolidation of requirements, and provide for more efficient use of scarce resources (dollars). Several authors referenced in this report alluded to the fact that during OEF and OIF, the Services resorted to brute force logistics to support the military operations. This characterization of logistics support is reflective of an era when the Services pushed massive stockpiles of material and equipment to the theater of operations. This type of logistics support wasted critical funds and resources. EAs can alleviate

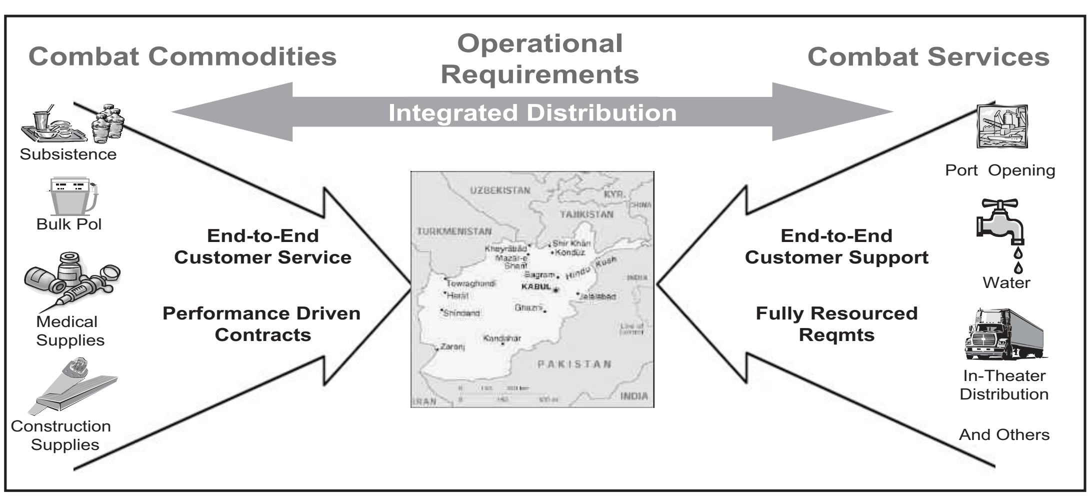


Figure 5. Executive Agents[101]

these types of problems for the commodities noted. The designation of EAs requires that the supplier collaborate across the Services and Agencies to determine requirements through mutual agreements. In doing so, brute force logistics for these three commodities should ultimately be a thing of the past.

The *Focused Logistics Campaign Plan* and the *Operational Sense and Respond Logistics Concept Plan* are solid roadmaps for transforming logistics. The basic tenets of the two plans include the need to make logistics more agile, more responsive, more accurate, and more reliable across the full spectrum of military operations. The designation of logistics EAs is but one small step in the overall logistics transformation process. It is, however, one means to enhance support to the Joint warfighter. Additionally, after DoD reviews the merits of these EA designations over time, DoD may find it prudent to designate EAs for other common commodities such as military clothing, and repair parts (consumable items). It is therefore the recommendation that DoD continues to designate logistics EAs for common use commodities where the benefits can be readily realized.

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The Themes of US Military Logistics

From a historical perspective, ten major themes stand out in modern US military logistics.

- The tendency to neglect logistics in peacetime and expand hastily to respond to military situations or conflict.
- The increasing importance of logistics in terms of strategy and tactics. Since the turn of the century, logistical considerations increasingly have dominated both the formulation and execution of strategy and tactics.
- The growth in both complexity and scale of logistics in the 20th century. Rapid advances in technology and the speed and lethality associated with modern warfare have increased both the complexity and scale of logistics support.
- The need for cooperative logistics to support allied or coalition warfare. Virtually every war involving US forces since World War I has involved providing or, in some cases, receiving logistics support from allies or coalition partners. In peacetime, there has been an increasing reliance on host-nation support and burden sharing.
- Increasing specialization in logistics. The demands of modern warfare have increased the level of specialization among support forces.
- The growing tooth-to-tail ratio and logistics footprint issues associated with modern warfare. Modern, complex, mechanized, and technologically sophisticated military forces, capable of operating in every conceivable worldwide environment, require that a significant portion, if not the majority of it, be dedicated to providing logistics support to a relatively small operational component. At odds with this is the need to reduce the logistics footprint in order to achieve the rapid project of military power.
- The increasing number of civilians needed to provide adequate logistics support to military forces. Two subthemes dominate this area: first, unlike the first half of the 20th century, less reliance on the use of uniformed military logistics personnel and, second, the increasing importance of civilians in senior management positions.
- The centralization of logistics planning functions and a parallel effort to increase efficiency by organizing along functional rather than commodity lines.
- The application of civilian business processes and just-in-time delivery principles, coupled with the elimination of large stocks of spares.
- Competitive sourcing and privatization initiatives that replace traditional military logistics support with support from the private business sector.

Looking at the Best Way to Get There: Comparing the Cost Effectiveness of Two Means in Moving Aircraft Spares

Captain Jason L. Mascuilli, USAF

Background

During their 8 December 2001 meeting, the Strategic Distribution Management Initiative (SDMI) Board of Directors raised the issue of the Air Force's frequent use of premium transportation versus the use of SDMI transportation from its air logistics centers. SDMI was established to better streamline Department of Defense distribution and logistics. SDMI, now known as Strategic Distribution (SD), is a joint venture between United States Transportation Command and the Defense Logistics Agency (DLA).

In response to those issues, the Air Force Logistics Management Agency (AFLMA) completed a project entitled, *Review and Analysis of the Air Force's Use of Premium Transportation* (LT200135100) in July 2002. In that study, AFLMA compared the transportation and inventory costs of moving all Air Force-managed reparables using the cheapest available transportation option to the costs of using Worldwide Express (WWX) transportation options, which are faster but more expensive. The study concluded that WWX transportation is still more cost-effective than traditional *slow* transportation when moving Air Force-managed reparables.

Subsequently, the Air Force Directorate of Logistics Readiness (AF/ILG) tasked AFLMA to examine the cost-and-ship-time difference between WWX and SD-managed transportation and to limit the study to Air Force-managed reparables going from the continental United States (CONUS) to locations outside the continental United States (OCONUS). This was done to give a better comparison between SD and WWX in the movement of reparables. AFLMA was tasked to examine two specific routes from CONUS to OCONUS that would represent all CONUS to OCONUS traffic. This study was completed to comply with AF/ILG's direction.

With this direction, an analysis was conducted to determine, from a cost perspective, if SD is a viable alternative to WWX in the movement of reparables from air logistics centers to overseas locations.

Acronyms

AFLMA - Air Force Logistics Management Agency
AMC - Air Mobility Command
APOE - Aerial Port of Embarkation
CONUS - Continental United States
DLA - Defense Logistics Agency
FY - Fiscal Year
OCONUS - Outside the Continental United States
SD - Strategic Distribution
SDMI - Strategic Distribution Management Initiative
USEUCOM - United States European Command
USPACOM - United States Pacific Command
WWX - Worldwide Express

Research Methodology

The study was completed in three areas of analysis. First was the transportation cost analysis portion. The following steps were taken to analyze the cost difference between WWX and Air Mobility Command (AMC) SD.

- Identify a few selected routes to use as representative of all traffic from CONUS to each of the OCONUS regions.
- Identify a few shipment weights to use as representative of the weight of every shipment.
- Determine AMC's rate for each of the routes and each of the shipments.
- Find the average WWX rate for each of the routes and each of the shipments.
- Find the total weight of material shipped out of Air Force depots.
- Determine the percentage of material shipped to each of the OCONUS regions.
- Determine the percentage of total material to be represented by each of the shipment weights.
- Determine the total weight of material moved into each region, by shipment weight.
- Determine the total cost to move these shipments via both WWX and AMC/SD.
- Determine cost difference between WWX and AMC/SD.

Second, we analyzed the shipping time of reparable items through the two different means compared in this study. We obtained AMC shipping time data and the average ship time for the high-priority shipments. The shipping time was calculated, using a 2-day estimated ship time from Tinker Air Force Base, Oklahoma, to the aerial ports of embarkation (APOE). Then, the difference between the WWX shipping time and the AMC/SD shipping time for each theater was calculated.

Finally, the ship-time difference was inserted into the Aircraft Availability Model and the change in inventory cost to use SD versus WWX was determined.

Transportation Cost Analysis

We estimated the cost of moving Air Force-managed reparable items from CONUS to OCONUS by using the costs for a single, notional route from Tinker to an OCONUS location in each theater, then extending the costs for this route to all CONUS to OCONUS Air Force-managed reparable traffic.

The first step was to estimate the costs for individual shipments. Given the time constraints of the study, we built a table of cost differences for a few shipments (described by weight) moving on the selected route for each theater. The route for the European theater was from Tinker to Aviano Air Base (AB), Italy. The route for the Pacific theater was from Tinker to Kadena AB, Japan. The SD route for the United States European Command (USEUCOM) was a scheduled truck from Tinker to Dover AFB, Delaware then AMC airlift to Ramstein AB, Germany; then shipped via either truck or air to Aviano. The SD route for the United States Pacific Command (USPACOM) was a scheduled truck from Tinker to Travis AFB, California; then AMC airlift to Kadena. Table 1 shows the costs for each shipment weight. For USEUCOM and USPACOM columns, the numbers are the differences between the average of the three WWX carrier rates and the rate SD charged from Tinker to the final destination. The SD is simply the weight of the shipment times the rate ($1.69 per pound to Kadena—$1.71 per pound to Aviano).

The estimated cost difference for the different shipment weights is shown in Table 2. A positive value indicates the WWX rate was more expensive than the AMC/SD rate, while a negative value in the table indicates the AMC/SD rate was greater than the WWX rate. It is important to note three things about the SD rates used in this study. First, the rates used in this study were significantly less than the published rates ($1.69 per pound versus $2.74 per pound to Kadena and $1.71 per pound versus $2.13 per pound to Aviano). Second, these low rates included the cost for fast shipment (guaranteed 2-day trucking) from origin to destination in the CONUS. Finally, the rates included the cost for intratheater shipping in the OCONUS regions as well. All three of these assumptions favor the SD option. These rates were provided by US Transportation Command specifically for this study and were based on the assumption that, if the SD option were used, traffic would increase along the specified routes, thereby resulting in lower SD rates.

The next step was to estimate the distribution of shipments by weight. RAND sent the AFLMA data on Air Force shipments moved during fiscal year (FY) 01, including shipment weight. To estimate the weight distribution of shipments of Air Force-managed items, AFLMA filtered out all the shipments not originating from an Air Force depot. Every shipment was put into one of the weight categories shown in Table 2. The percentage of shipments for each category, by theater, is shown in Table 3.

Next, using readiness-based leveling data, we determined the total number of outbound shipments of Air Force-managed items moved to the various theaters from the air logistics centers (excluding lateral support and retrograde shipments) during FY01. This information is shown in Table 4.

Finally, to estimate the upper bound on the total savings if all Air Force-managed items were shipped via routine transportation instead of premium commercial transportation, we made the following assumptions.

- All the items shown in Table 4 were moved using premium transportation
- The transportation savings for all shipments weighing between 0 and 10 pounds were approximated using the savings for a 10-pound shipment, shipments between 11 and 20 pounds were approximated using the savings for a 20-pound shipment, and so on. This process overstated the transportation savings because very few of the shipments weighed exactly the amount used in the calculation. A very large majority weighed less than 10 pounds, and the savings for a 5-pound shipment would be less than for a 10-pound shipment since transportation charges are based on exact weight, and not on weight-range categories

Given these assumptions, to estimate an upper bound on transportation savings, we multiplied the number of shipments moved in a theater (Table 4) by the percentage of those shipments weighing a certain number of pounds (Table 3). We then multiplied that number by the savings per shipment for that type of item (Table 2). The final results are shown in Table 5. A positive

	WWX		AMC/SD	
Weight	EUCOM	PACOM	EUCOM	PACOM
0-10 lbs	$25.08	$25.30	$17.10	$16.90
11-20 lbs	$40.16	$40.85	$34.20	$33.80
21-30 lbs	$59.01	$57.61	$51.30	$50.70
31-40 lbs	$70.00	$68.26	$68.40	$67.60
41-50 lbs	$80.99	$83.67	$85.50	$84.50
51-60 lbs	$96.63	$98.50	$102.60	$101.40
61-70 lbs	$107.50	$107.32	$119.70	$118.30
70-80 lbs	$122.69	$117.83	$136.80	$135.20
81-90 lbs	$139.77	$139.68	$153.90	$152.10
91-100 lbs	$165.97	$170.14	$171.00	$169.00
101-110 lbs	$183.28	$187.98	$188.10	$185.90
111-120 lbs	$200.59	$205.82	$205.20	$202.80
121-130 lbs	$217.89	$223.65	$222.30	$219.70
131-140 lbs	$235.20	$241.49	$239.40	$236.60
141-150 lbs	$252.51	$259.33	$256.50	$253.50

Table 1. Costs per Shipment

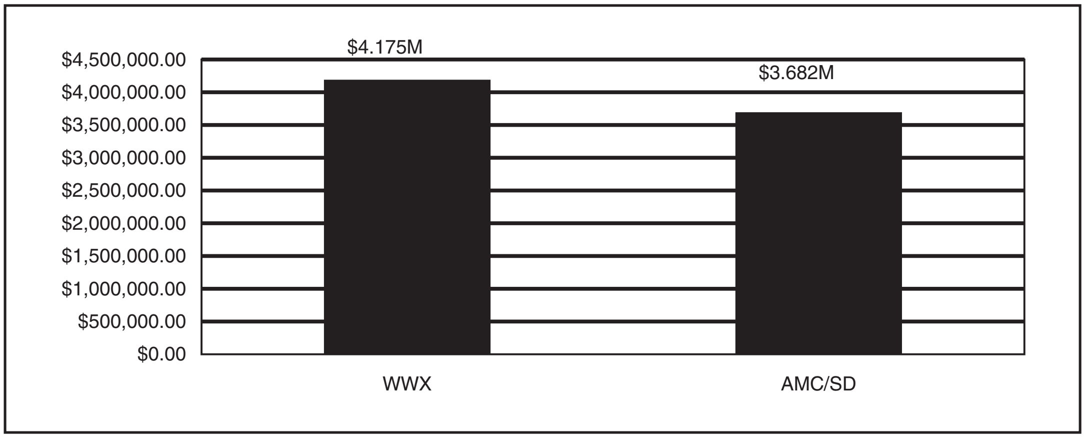

Figure 1. Comparison of Transportation Costs

Weight	EUCOM	PACOM
0-10 lbs	$7.98	$8.40
11-20 lbs	$5.96	$7.05
21-30 lbs	$7.71	$6.91
31-40 lbs	$1.60	$0.66
41-50 lbs	-$4.51	-$0.83
51-60 lbs	-$5.97	-$2.90
61-70 lbs	-$12.20	-$10.98
70-80 lbs	-$14.11	-$17.37
81-90 lbs	-$14.13	-$12.42
91-100 lbs	-$5.03	$1.14
101-110 lbs	-$4.82	$2.08
111-120 lbs	-$4.61	$3.02
121-130 lbs	-$4.41	$3.95
131-140 lbs	-$4.20	$4.89
141-150 lbs	-$3.99	$5.83

Table 2. Transportation Cost Difference for Individual Shipments

Weight	EUCOM	PACOM
0-10 lbs	57.47%	54.84%
11-20 lbs	11.16%	12.00%
21-30 lbs	7.00%	7.39%
31-40 lbs	4.30%	4.18%
41-50 lbs	2.45%	2.67%
51-60 lbs	1.89%	1.64%
61-70 lbs	1.46%	1.89%
70-80 lbs	2.22%	1.53%
81-90 lbs	1.18%	1.07%
91-100 lbs	1.41%	0.85%
101-110 lbs	1.41%	1.00%
111-120 lbs	0.56%	0.57%
121-130 lbs	0.23%	0.67%
131-140 lbs	0.18%	0.46%
141-150 lbs	0.56%	0.32%

Table 3. Percentage of Air Force Shipments by Weight Category and Theater

	EUCOM Number	PACOM Number
Items Moved	41840	54121

Table 4. Number of Shipments Moved

value shows using WWX would be more expensive than AMC/SD, while a negative value indicates AMC/SD would be more expensive than WWX. The maximum potential transportation savings for using AMC/SD versus WWX would have been $493,615.

To determine total estimated transportation costs, we multiplied the number of shipments moved to a theater (Table 3) by the percentage of those shipments weighing a certain number of pounds (Table 2). We then multiplied that number by the cost per shipment (Table 1). Table 6 shows the total cost for both theaters for WWX and AMC/SD. Table 7 shows the estimated annual total cost for moving reparables via WWX and AMC/SD overseas. Figure 1 compares the costs graphically.

Ship-Time Analysis

The next portion of the analysis compared the ship time of WWX to the SD system. We analyzed WWX shipments for October 2001 from Oklahoma City Air Logistics Center, to Aviano (130 shipments) and Kadena (63 shipments). We also analyzed AMC shipments for October 2001 – December 2001 from Travis to Kadena (3,006 shipments) and Dover to Aviano (1,562 shipments). For the AMC routing, we included only shipments with a transportation priority of 1 or 2 and an air special handling code of Z, meaning no special handling was required. This was done to ensure the most accurate comparison possible between WWX and AMC/SD. AMC shipments meeting these criteria were most like WWX shipments.

For the shipments described above, we found the mean shipment time. For the WWX shipments, we calculated the mean days from when the shipment was picked up to when it was delivered. For the AMC shipments, we found the mean days from when the shipment arrived at the APOE to when it arrived at the

Weight	EUCOM	PACOM
0-10 lbs	$191.822.68	$249,311.63
11-20 lbs	$27,829.29	$45,786.37
21-30 lbs	$22,581.05	$27,636.83
31-40 lbs	$2,878.59	$1,493.09
41-50 lbs	-$4,623.11	-$1.199.38
51-60 lbs	-$4,720.93	-$2,573.99
61-70 lbs	-$7,452.54	-$11.231.30
70-80 lbs	-$13,106.05	-$14,383.25
81-90 lbs	-$6,976.15	-$7,192.36
91-100 lbs	-$2,967.42	$524.43
101-110 lbs	-$2,843.53	$1,125.72
111-120 lbs	-$1,080.14	$931.64
121-130 lbs	-$424.38	$1,432.31
131-140 lbs	-$316.31	$1,217.40
141-150 lbs	-$934.87	$1,009.68
Theater Transportation Cost Difference	$199,726.17	$293,888.83
Total Transportation Cost Difference	$493,615.00	

Table 5. Total Transportation Cost Difference

	WWX		AMC/SD	
Weight	EUCOM	PACOM	EUCOM	PACOM
0-10 lbs	$603,060	$750,903	$411,177	$501,591
11-20 lbs	$187,521	$265,301	$159,692	$219,515
21-30 lbs	$172,828	$230,414	$150,247	$202,777
31-40 lbs	$125,938	$154,422	$123,060	$152,929
41-50 lbs	$83,021	$120,906	$87,644	$122,105
51-60 lbs	$76,413	$87,427	$81,134	$90,001
61-70 lbs	$65,668	$109,776	$73,120	$121,008
70-80 lbs	$113,960	$97,569	$127,066	$111,953
81-90 lbs	$69,006	$80,888	475,982	$88,080
91-100 lbs	$97,913	$78,269	$100,880	$77,745
101-110 lbs	$108,125	$101,737	$110,968	$100,611
111-120 lbs	$46,999	$63,493	$48,079	$62,562
121-130 lbs	$20,968	$81,098	$21,392	$79,666
131-140 lbs	$17,713	$60,121	$18,030	$58,903
141-150 lbs	$59,164	$44,913	$60,009	$43,903
Total	$1,848,298	$2,327,236	$1,648,572	$2,033,347

Table 6. Total Estimated Transportation Costs by Theater and Weight

WWX	AMC/SD
$4,175,534.22	$3,681,919.23

Table 7. Total Estimated Costs

	WWX	AMC/SD
EUCOM	3.53 days	7.47 days
PACOM	3.61 days	4.49 days

Table 8. Ship Times

final destination. We then added 2 days to the shipment time to represent the trucking time from Tinker to either Dover or Travis. The results are shown in Table 8. USEUCOM represents shipments to Aviano, while USPACOM represents shipments to Kadena.

Inventory Cost Analysis

Assuming the order time for an item remained constant, we applied the ship-time difference between WWX and SD to determine the impact on inventory. To determine the cost impact on inventory, we assumed that the times for the routes were representative of ship time for all routes in the respective theaters. We then weighted the ship-time increase for each theater by the percentage of worldwide shipments to each of those theaters to determine the impact on worldwide ship time. Shipments to USEUCOM represented 6.4 percent of all shipments, while 8.3 percent of the shipments were to USPACOM. We multiplied the percentage of shipments to a specific theater by the increase in ship time (USEUCOM: 0.064 X 3.94 days = 0.253; USPACOM: 0.083 X 0.88 days = 0.073). We then summed the times, with 0 representing CONUS (0.253 + 0.073 + 0 = 0.326, rounded to 0.33). Therefore, using AMC/SD would result in a worldwide increase in ship time of 0.33 days. We used March 20, 2001 data from the Aircraft Availability Model (provided by the Logistics Management Institute) to estimate the impact of the increased worldwide ship time on the Air Force's reparable inventory. We estimated the 0.33-day increase in ship time for reparables from the ALCs would require an additional $7,679,721 in reparable inventory.

Using SD could save the Air Force $493,615 in transportation costs annually. However, ensuring no degradation in service would require an additional $7.68M in reparable inventory. Even with $493,615 in cost savings, it would take 15.67 years for the transportation cost savings realized by using AMC/SD to pay for the additional reparable inventory needed to maintain current levels of service.

Conclusion

Based on the analysis, SD was shown to be less expensive when looking at strictly transportation costs. However, even with lower transportation costs, SD is not cost effective. The reason for this is reparable inventories would have to increase, meaning additional inventory would have to be bought and maintained to overcome the slower ship time of SD versus the ship time of WWX. Therefore, SD is not a viable alternative to WWX for moving eligible reparables from air logistics centers to overseas locations.

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notable quotes

Army officers are intelligent—give them the bare tree, let them supply the leaves.

—Gen George C. Marshall

EXPLORING THE HEART OF LOGISTICS

Changing the Face of Unit Deployment Manager Responsibilities

Captain Robert E. Overstreet, USAF
Captain Tamiko Ritschel, USAF

Background

A unit's ability to deploy rapidly and effectively underpins air and space expeditionary force (AEF) capabilities. Former Air Force Chief of Staff, General John P. Jumper, put it succinctly, "… everyone in the Air Force must understand that the day-to-day operation of the Air Force is absolutely set to the rhythm of the deploying AEF force packages … the natural state of our Air Force when we are *doing business* is not home station operations but deployed operations."[1]

In the Air Force, unit deployment managers (UDMs) shoulder the deployment workload at the unit level. Air Force Instruction 10-403, *Deployment Planning and Execution*, paragraph 1.6.1.5, requires unit commanders to appoint a primary and alternate UDM. UDMs are responsible for educating the unit on its expeditionary role and ensuring personnel and equipment are ready to deploy. They lead efforts to construct and maintain unit type codes (UTCs), monitor the readiness of each unit member, act as the commander's point of contact, and interface with the installation deployment officer (IDO).

The *Air and Space Expeditionary Force Presence Policy,* signed in 2004 by then Secretary of the Air Force, James G. Roche, defines the structure and role of the air and space expeditionary force within the environment of joint warfare. The demands of this policy and the Global War on Terror have significantly altered squadron deployment management requirements, thus expanding the role and increasing the value of the UDM. This new environment challenges senior Air Force leadership to find a better way to meet the squadron's deployment management needs. The Air Force Logistics Management Agency (AFLMA) was tasked to assess this new environment and analyze possible alternatives to the current way of doing business.

The AFLMA study team constructed a hierarchy representing what the decision maker values when assessing alternatives. This methodology closely resembles value-focused thinking (VFT), an approach to decision making made popular by Dr Ralph L. Keeney. In theory, unlimited access to the sole decision maker or decision-making body is essential. However, developing the hierarchy for this study using a single decision maker or decision-making body was not possible for two reasons. First, a single decision-making body does not exist. Implementing recommendations resulting from this study would entail approval at many levels. Second, all the players involved in the decision do not have the time to devote the proper attention necessary to fully develop a hierarchy. Therefore, this analysis relies on the study team's expertise and non-partiality acting on the behalf of the decision-making body. The study team used insight from survey responses and subject matter experts (SMEs) as well as inputs from key personnel in the decision-making body. As Dr Keeney states, "It is useful, and sometimes necessary, to quantify values from interested and knowledgeable parties about a given decision context. Such a quantification, including the specification of objectives on which it is based may be of considerable help to any of the parties eventually involved in the decision process."[2]

The study team considered four alternatives generated through brainstorming sessions, which were subsequently approved by members of our decision-making body.

- Retaining UDM responsibilities as an additional duty assigned to an individual within the unit or the *as-is* alternative
- Creating a new Air Force specialty code (AFSC) to handle UDM responsibilities
- Assigning these duties to the logistics plans career field; and
- Creating a special duty assignment

(Continued on page 59)

Acronyms

AEF - Air and Space Expeditionary Force
AFLMA - Air Force Logistics Management Agency
AFSC - Air Force Specialty Code
ART - AEF Reporting Tool
CDF - Cargo Deployment Function
CEM - Chief Enlisted Manager
IDO - Installation Deployment Officer
JI - Joint Inspection
LOGMOD - Logistics Module
PDF - Personnel Deployment Function
SME - Subject Matter Expert
SORTS - Status of Resources and Training System
UDM - Unit Deployment Manager
UTC - Unit Type Code
VFT - Value-Focused Training

Because the Air Force plans to fly many aircraft for an extended period of time, there is an increasing demand for more accurate knowledge about the current and future structural condition of aircraft and the associated risks of structural failure.

contemporary issues

A Survey of Aircraft Structural-Life Management Programs in the US Navy, the Canadian Forces, and the US Air Force

In a "Survey of Aircraft Structural-Life Management Programs," the authors examine two different approaches to monitoring the structural integrity of an aircraft during the course of its life cycle: Safe-Life Approach and Damage Tolerance Concept. Concerns over an aircraft's structural integrity include increased maintenance workload, declining aircraft readiness, and the increased safety risk. The authors explore each program's policies, assessments, and certification processes. Finally, they suggest adaptations of approaches used by the Navy or the Canadian Air Force to enhance the Air Force's structural integrity program.

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Structure-Life Management

A Survey of Programs in the US Navy, the Canadian Forces, and the US Air Force

Yool Kim, PhD
Colonel Stephen Sheehy, USAF
Commander Darryl Lenhardt, USN

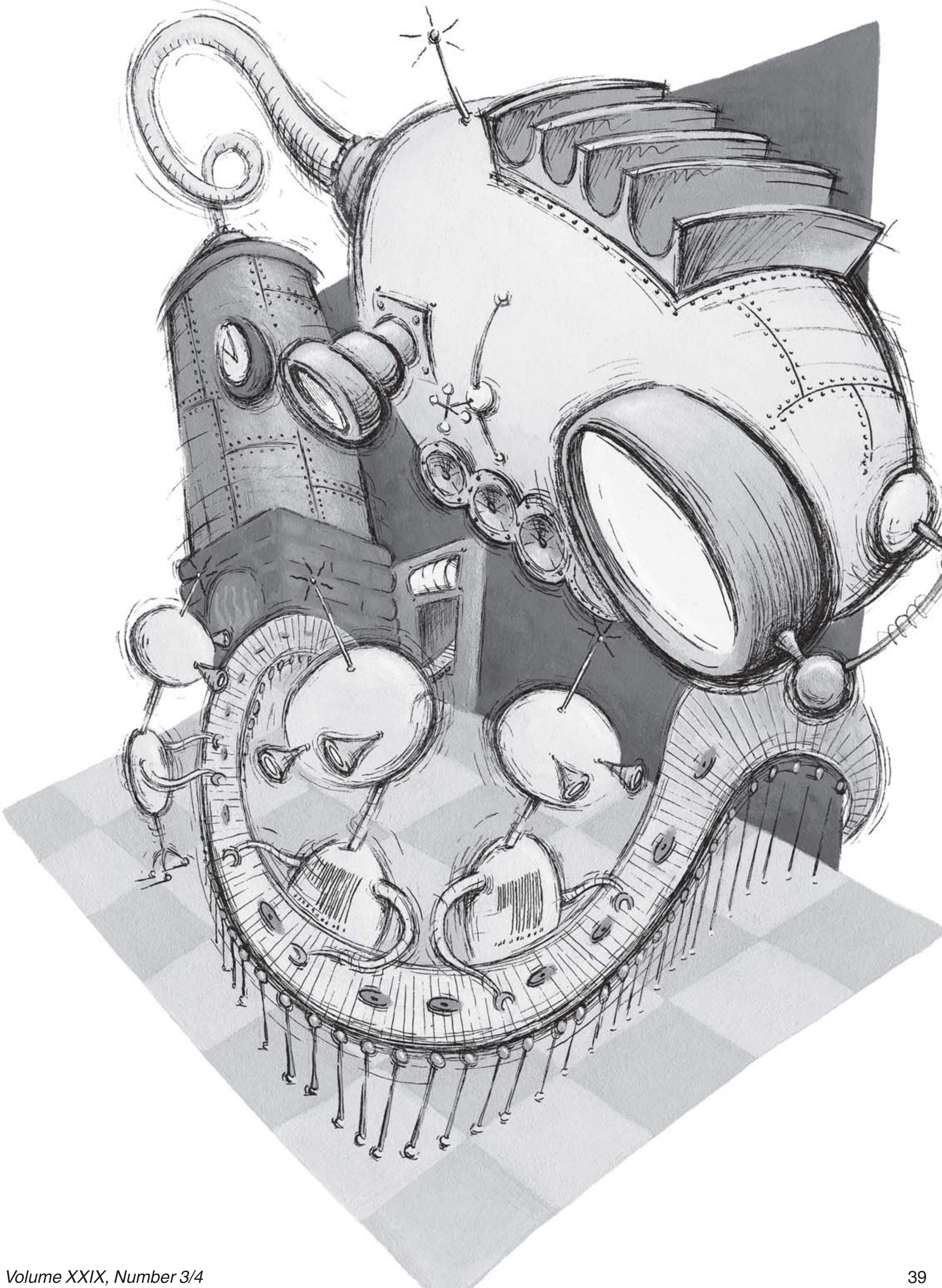
Introduction

Since 1958, the Air Force has relied on its Aircraft Structural Integrity Program (ASIP) to achieve structural safety of its aircraft. The ASIP's overarching objective is to prevent structural failures cost effectively and without the loss of mission capability. The ASIP provides a framework for establishing and sustaining structural integrity throughout the aircraft's life. During the acquisition phase, ASIP activities involve design, analysis, and tests to ensure that the aircraft structure is adequate to operate as intended. During the sustainment phase, the ASIP activities involve data collection, analysis, and tests needed to continually plan the sustainment activities such as maintenance and modifications to ensure that the structure remains safe until retirement. These activities provide information about structural conditions that can be used to help in fleet management decisions. As such, the ASIP is a key contributor to the Air Force's Force Management processes.

In recent years, some concerns have been raised about ASIP's capability to continue meeting the future needs of the Air Force due to the impact of an aging force, budget pressures, and diminishing ASIP regulatory power. The Air Force owns and operates approximately 6,000 aircraft to meet its force requirements. The average age of the force is approximately 22 years old, and the average age is expected to continue rising.[1] Many of the older aircraft face aging issues, such as structural deteriorations of the airframe, and many aircraft are expected to encounter them as the Air Force plans to keep the aircraft in service for an extended period of time. Meanwhile, there are growing concerns in the Air Force that structural deteriorations in aging aircraft will lead to increased maintenance workload, declining aircraft readiness, and increased safety risk.[2]

Because the Air Force plans to fly many aircraft for an extended period of time, there is an increasing demand for more accurate knowledge about the current and future structural condition of aircraft and the associated risks of structural failure. The need for engineering capabilities both in terms of research and development and engineering analysis is increasing as age-related problems grow. The 1997 National Research Council study on the Air Force's aging force, as well as the engineering community at recent ASIP conferences, have voiced concerns that budget pressures, rather than structural needs, are driving the level of ASIP implementation as fleet managers need to allocate their resources between sustainment of aging airframes and other aging aircraft subsystems (for example, modernization of avionics).[3, 4]

Moreover, ASIP's regulatory power has diminished over the years as a result of reforms in the 1990s to minimize government regulations in acquisition.[5] Prior to these acquisition reforms, Air Force regulation (AFR) 80-13 (rescinded 1 June 1994 and replaced with Air Force Instruction (AFI) 63-1001, *Aircraft Structural Integrity*



Program) and the ASIP standard, MIL-STD-1530, were used to enforce ASIP. However, with the acquisition reform, the AFR was converted to an Air Force instruction, and the Air Force converted the ASIP military standard (MIL-STD-1530) to a military handbook (MIL-HDBK-1530B) that could no longer be cited as a contractual requirement. As a result, the industry and the contractors, as well as the System Program Offices (SPOs) who carry out the ASIP, interpret the former requirements as guidelines.

At recent ASIP conferences, the engineering community also expressed that one of the main challenges in structural-life management processes has been communicating structural integrity issues to decision makers. Several potential causes were cited.

- Lack of technical understanding by decision makers
- Insufficient data on structural conditions
- Lack of resources to gather sufficient information on structural conditions
- Lack of outlet for communicating key structural integrity issues to decision makers

Acronyms

AFI – Air Force Instruction
AFPD – Air Force Policy Directive
AFR – Air Force Regulation
ASIP – Aircraft Structural Integrity Program
ASLS – Aircraft Structural Life Surveillance
CF – Canadian Forces
FLE – Fatigue Life Expended
FLEI – Fatigue Life Expended Index
FLI – Fatigue Life Index
FSMP – Force Structural Maintenance Plan
IAT – Individual Aircraft Tracking
L/ESS – Loads and Environmental Spectra Survey
MDS – Mission, Design, Series
MIL-HDBK – Military Handbook
MIL-STD – Military Standard
NAVAIR – Naval Air Systems
PMA – Program Manager for Air
POM – Program Objective Memorandum
SAF – Secretary of the Air Force
SAFE – Structural Assessment of Fatigue Effects
SLAP – Structural Life Assessment Program
SLEP – Service Life Extension Program
SPD – System Program Director
SPO – System Program Office
TAA – Technical Airworthiness Authority
WSM – Weapon System Manager

As a result, decision makers may not have full visibility regarding structural conditions and may lack understanding of the consequences of inadequate ASIP implementation.

From the decision makers' perspective, there may be no concern regarding ASIP's effectiveness, since there have not been catastrophic structural failures in recent years. However, as we look prospectively, the concern is that inadequate ASIP implementation (for example, omission of or incomplete ASIP tasks) may degrade the effectiveness of ASIP and adversely impact the force's operational effectiveness, aircraft safety, and sustainment costs.

The Air Force has initiated several actions to address some of these challenges. For example, in February, 2004 the Aeronautical Systems Center's Engineering Directorate (ASC/EN) converted MIL-HDBK-1530B back to a military standard that can once again be used as a contractual requirement. This will reestablish some standardization and control of the ASIP.

Scope

In our research, we surveyed aircraft structural-life management programs in the Navy, the Canadian Forces (CF), and the Air Force to provide insights and guidance on how the Air Force can continue to strengthen the ASIP to meet its objectives in the presence of current challenges and needs. We focused on these Services' approaches to regulations, communications between structural-life management authorities, and resource management to qualitatively assess the implications of the different approaches. We focused on ASIP during the sustainment phase to address current ASIP challenges in sustaining the aging force. Hence the research scope is also limited to aircraft that are no longer being procured.[6]

Technical Basis of Aircraft Structural-Life Management

Fatigue is one of the primary damage mechanisms that cause an aircraft structure to deteriorate during its lifetime. It is a process in which damage accumulates in the material subjected to alternating or cyclic loading, such as landings, takeoffs, and various maneuvers.[7] This damage may culminate in cracks, which will eventually lead to complete fracture after a sufficient number of cycles of loads. Thus one of the key design criteria for an aircraft is that it endures accumulated fatigue damage over its service life to prevent structural failures.

There are two fatigue-based design concepts that may be used to account for fatigue damage in aircraft: safe-life and damage tolerance (Figure 1). These fatigue design approaches differ in their models of the damage growth process, their assumptions about the initial material condition, and the failure criteria used to establish the aircraft's original design service life.

The Navy and the CF's safe-life approach assumes that no fatigue cracks will exist in the structure during the specified lifetime for safe operation, and the design service life ends prior to crack initiation. The Navy and the CF define the crack *initiation* state as the point where a crack length reaches 0.01 inch. As a result, the safe-life approach requires minimal routine inspection for fatigue cracks.

The mean time for a 0.01-inch crack length to develop is determined from full-scale fatigue tests, in which expected service loads are simulated and applied to an aircraft in a laboratory environment. This test-demonstrated fatigue life (time to *failure*, which the Navy and the CF define as the crack "initiation") is divided by a life reduction factor of 2 to arrive at the design service life. The life reduction factor accounts for variability in material properties and fatigue loads.

The damage tolerance concept assumes that potential fatigue cracks may exist in critical locations in fracture-critical parts due to defects from manufacturing and in-service activities (for example, during repair), and that these flaws will result in crack growth during the aircraft service life.[8] Under damage tolerance, the assumed initial flaw in the structure must not grow to a critical size to cause structural failure for a period of unrepaired service usage. The critical size is determined based on the minimum residual strength required for the structure to withstand the relatively rare occurrence of a design limit load. The test-demonstrated fatigue life, the time it takes for an initial flaw to grow to a critical size, is divided by a life reduction factor of 2 to arrive at the design service life. Inspection intervals are then determined to ensure that a crack does not reach its critical size without being detected.

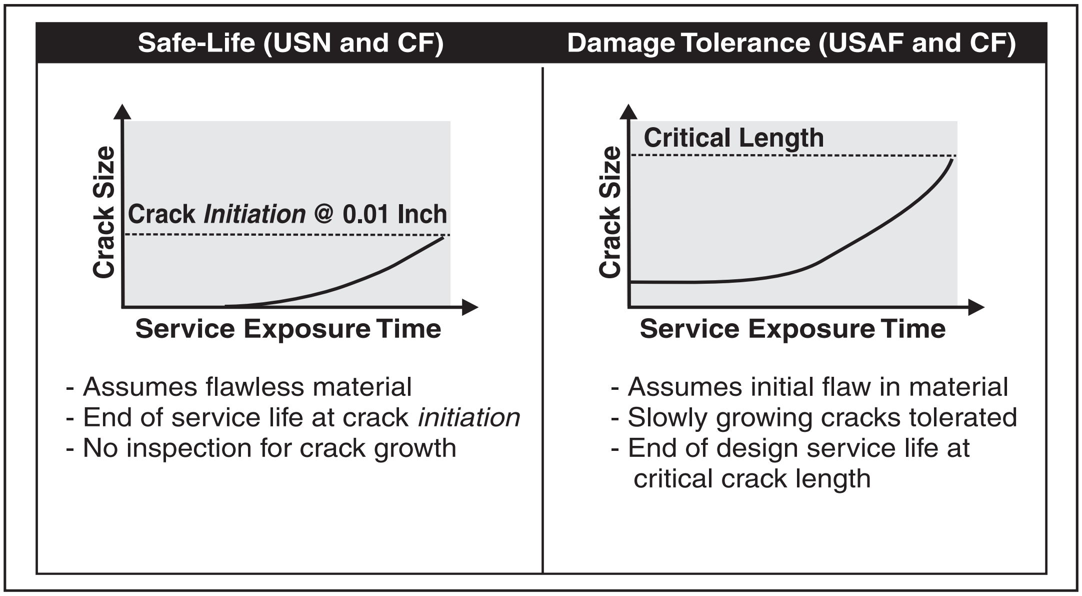


Figure 1. Comparison of Safe-Life and Damage Tolerance Fatigue Design Concepts

The US Navy's Aircraft Structural-Life Management Process

The Navy operates approximately 2,000 fixed-wing aircraft and about 20 different aircraft types, many based on carriers.[9] The Navy takes the safe-life approach to structural-life management partly because of the limited space and facilities on carriers for inspection and repairs. Implementation of the safe-life approach provides a maintenance-free operation period without compromising safety.

The Navy has an explicit policy on structural-life management. The governing policy behind the Navy's approach to structural-life management is that the aircraft must not exceed the structural life limits during service to ensure structural safety. A Naval Air Systems Command (NAVAIR) instruction outlines the policy, rules, and procedures on establishing and maintaining structural integrity of all Navy aircraft.[10] The instruction describes the principal elements of the structural-life management and assigns responsibilities to various organizations. A centralized program, the Aircraft Structural-Life Surveillance (ASLS) Program, carries out the majority of the structural-life management tasks for all Navy aircraft. The ASLS Program has three components: Structural Assessment of Fatigue Effects (SAFE) Program, Structural Life Assessment Program (SLAP), and Service Life Extension Program (SLEP).

The program manager for Air (PMA) is responsible for the total life-cycle management of the designated fleet. The PMA has the ownership and decision authority on structural-life management of the fleet (except for fatigue life tracking). The NAVAIR structures division under the NAVAIR air vehicle department supports the PMAs in structural-life management of their aircraft and carries out the ASLS Program. The NAVAIR structures division also has a regulatory responsibility on the technical aspect of structural-life management.

All of the NAVAIR structures engineers and the PMAs work in a single facility at Patuxent River, Maryland.[11] The geographic collocation of these structural-life management authorities and the centralized ASLS Program promote information sharing and cross-fertilization across different program offices with respect to structures.

The Navy's structural-life management process is illustrated in Figure 2. The Navy establishes strict structural life limits for each aircraft type, or type/model/series, based on the fatigue life limits of the airframe and the critical components. To ensure that the aircraft do not exceed the fatigue life limits during service, the SAFE Program tracks individual aircraft fatigue life for all aircraft in terms of a standard quantifiable metric, fatigue life expended (FLE).[12] The FLE is the primary indicator in conveying the structural condition to those operating and supporting the aircraft. An FLE of 100 percent is the fatigue life limit.

The SAFE Program disseminates the individual FLE information for all aircraft in a formal report (SAFE report) every 3 months to a wide range of Navy organizations. Because the FLEs for all aircraft are visible to all the organizations involved in aircraft operation and support, as well as senior leadership, they have continual visibility of the state of each aircraft. The SAFE report is a key document in assisting decision makers in structural-life management. The report provides the fleet profile in terms of FLE distribution and thus it helps the PMAs in prioritizing modifications and phasing in and phasing out of a fleet.

Rigorous and accurate monitoring of fatigue life is critical to the Navy because under the safe-life approach, there is no routine inspection for cracks to validate the structural condition. The SAFE program has a dedicated funding line to enable an independent assessment of the aircraft's fatigue life and to ensure that this critical task is carried out.

After the fleet has been in service for a period of time or if the usage of the aircraft has significantly changed from the original design, the ASLS Program evaluates the current structural condition and verifies the remaining fatigue life of the fleet under the SLAP. A SLAP may involve a wide range of activities to reassess a fleet's structural life limit, such as an assessment of in-service usage, a teardown inspection, laboratory tests, and an analysis update. In some cases, a full-scale fatigue test may be conducted for the structural life assessment. A SLAP can be a multi-year effort, especially if a full-scale fatigue test is involved.[13]

In the past, SLAP results have shown that fatigue cracks have occurred earlier than predicted. As a result, the ASLS Program recommends a SLAP when a majority of the fleet has reached 50 percent FLE, such that there is sufficient lead time, in the event a service life extension is needed.

Upon reaching the structural life limit or 100 percent FLE, the Navy either chooses to retire the aircraft or extend the structural life by modification or replacement of critical components under the SLEP. Inspection is not a viable option in extending structural life because of the safe-life philosophy. Additionally, depending on the extent of the modifications or replacements, a new full-scale fatigue test is conducted to establish the extended structural life limit. Due to the explicit policy on structural-life limit, planning a SLAP and a SLEP in a timely manner is critical to minimize the risk of aircraft reaching the structural-life limits prior to a completion of necessary modifications.

The NAVAIR structures division is the final authority on structural integrity and must certify any structural changes to ensure that structural integrity is maintained until the structural life limit is reestablished. The Structures division determines the criteria for certification on a case-by-case basis (for example, structural analysis, component testing or full-scale fatigue tests). The division's role in certification of structural integrity provides an independent technical assessment on the PMA's resource allocation decisions, promoting checks and balance in the resource management process.

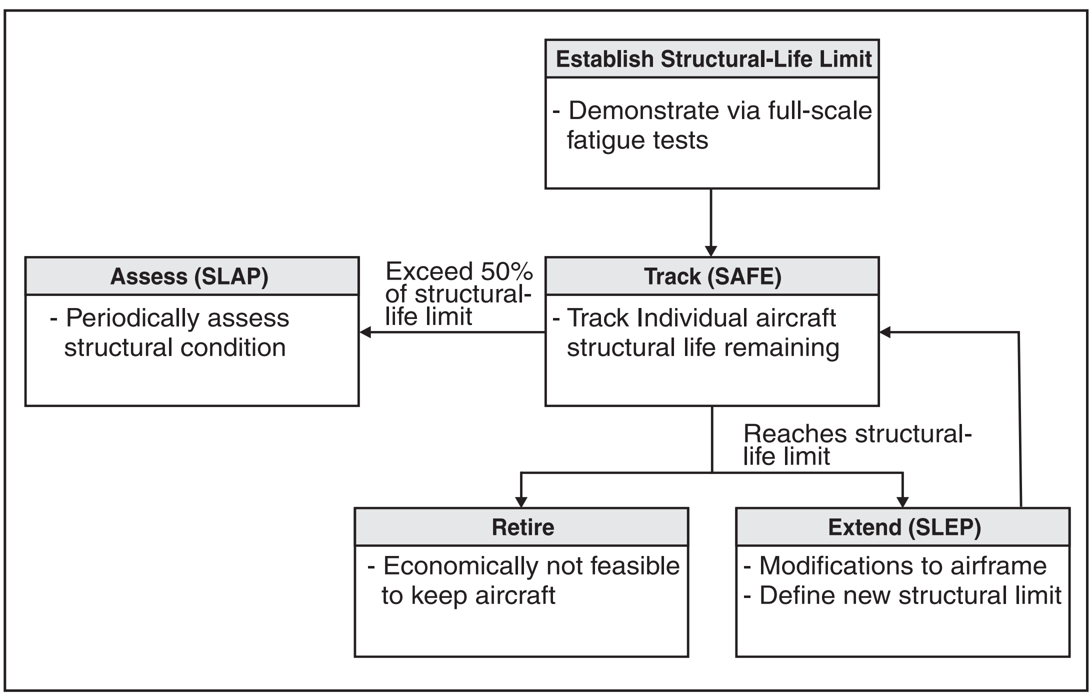


Figure 2. The US Navy Aircraft Structural-Life Management Process

The Canadian Forces' Aircraft Structural-Life Management Process

The CF operates approximately 350 fixed-wing aircraft and about a dozen different aircraft types in a land-based environment.[14] Because they are based on Navy designs, the CF had originally implemented the safe-life approach to structural-life management. As the CF has sought to extend the service lives of their aircraft, however, they have adopted the damage tolerance approach to ensure safety beyond the original design service life (beyond crack initiation). Unlike the Navy, the CF does not have carrier-based aircraft and thus implementing a routine inspection for cracks, as a result of the adoption of the damage-tolerance approach, was not a significant barrier.[15]

The CF's governing policy regarding structural integrity is broad and based on the concept of *airworthiness*. The CF defines *airworthiness* as demonstrating the achievement of minimum acceptable level of aviation safety.[16] This acceptable level is based on a compilation of requirements defined for each aircraft type in its *basis of certification*. With respect to structural integrity, the basis of certification is effectively the ASIP requirements. Every aircraft type must develop a basis of certification and comply with the standards in the basis of certification throughout its service life to demonstrate that the aircraft is airworthy. If the aircraft falls out of compliance with these standards, for example, by exceeding its fatigue life, a new basis of certification is required.

The CF takes a regulatory approach to structural-life management. An independent regulatory authority, the Technical Airworthiness Authority (TAA), provides regulations and oversight for all weapon systems' ASIPs and assesses compliance (Table 1). The basis of certification is used as a means to assess compliance. The weapon system managers (WSM) are responsible for the fleet management of their aircraft and are accountable for implementing ASIP. The WSM tailors the ASIP to the specific weapon system being managed, complying with the structural integrity-related regulations. Each WSM has an ASIP manager who executes the ASIP and supports the WSM on structural-life management. The TAA, the WSMs, and the ASIP managers are centrally collocated in a single site in Ottawa, Ontario.

The TAA evaluates ASIP compliance on a case-by-case basis via formal airworthiness monitoring and approval processes. Every aircraft type must initially receive an airworthiness approval prior to entering service via the airworthiness certification process. The TAA grants flight authority based on the airworthiness certification. Additionally, fleet management plans that impact the structural integrity, such as modifications and operational changes, require formal approvals by the TAA via the design change certification process. Because the initial basis of certification is only applicable to the initially specified configuration and usage, a design change (change in maintenance program, configuration, or mission) requires a new basis of certification.

The CF also incorporates formal program monitoring processes. During the annual Airworthiness Review Board meetings, the board, consisting of senior regulatory authorities, reviews the airworthiness status of all fleets and other airworthiness issues. The TAA also plans to conduct annual reviews of all fleets' ASIPs to monitor compliance.

The CF uses multiple types of information to convey the structural condition because airworthiness with respect to structural integrity requires meeting multiple requirements. Similar to the Navy, the CF-18 and CP-140 weapon system offices track remaining fatigue life of critical components for every aircraft.[17] The CF uses the fatigue life index (FLI) or fatigue life expended index (FLEI), which is equivalent to the Navy's FLE metric. However, unlike the Navy, there is no threshold on the FLI/FLEI due to the later adoption of the damage tolerance approach. As a result, exceeding an FLI of 100 percent does not mean that the aircraft is no longer airworthy. Airworthiness can be achieved by implementing a modified inspection program to monitor the component that has exceeded the FLI of 100%. Both CP-140 and CF-18 document the FLI/FLEI in their quarterly ASIP reports. The CF also uses risk (in terms of probability of structural failure) as a metric to convey the state of the structural condition.

The CF conducts periodic assessments to verify the aircraft structural condition during the service life, as necessary. For example, if the actual usage of aircraft is significantly altered from the design usage, reverification of structural condition may be required to substantiate airworthiness. The WSM and the ASIP manager choose the method of compliance by proposing tests or analysis procedures that the TAA must approve.

The ASIP manager updates the ASIP Master Plan at least annually. The plan outlines all of the required structural-life management tasks for both the near and long term. The master plan is based on the current and predicted future condition of the structure as well as the requirements in the basis of certification. These plans include updates in inspection, maintenance, and modifications. The WSM must approve the ASIP Master Plan, as the WSM authorizes and allocates the funds for ASIP and fleet management tasks.

The regulatory processes such as reviews and certification processes provide independent assessments on the WSM's resource allocation decisions as well as guide the WSM's prioritization of resource allocation. The regulatory processes also require much information to be communicated formally, such as documentation of critical information for traceability and planning purposes, as well as for compliance finding. In addition to formal communications, informal communications between the WSMs, the ASIP managers, and the TAA occur in various decision-making processes due to the working relationship. Although ASIP implementation is decentralized, geographic collocation leads to informal information sharing between ASIP managers, providing visibility across fleets and cross-fertilization across the ASIPs.

Technical Airworthiness Authority (ASIP Regulator)	Weapon System Manager (ASIP Implementer)
Establishes general rules and standards	Customizes ASIP plans for his/her weapon system
Assesses compliance and audits personnel and organization	Chooses suitable method of compliance
Accredits organization and delegates authorities	Authorizes funding of structural integrity-related tasks

Table 1. Responsibilities of the Canadian Forces' Structural-Life Management Authorities

The Air Force Aircraft Structural-Life Management Process

The Air Force operates about 6,000 aircraft and about 40 different aircraft types in a land-based environment.[18] It uses the damage tolerance approach to manage the structural life and to establish the maintenance plans for its aircraft.

The governing policy on ASIP is established in Air Force Policy Directive (AFPD) 63-10, *Aircraft Structural Integrity.* The policy is broad in that it requires the Air Force to "establish an ASIP for each aircraft weapon system it is acquiring or using," tailored to a specific weapon system. The corresponding Air Force Instruction 63-1001, *Aircraft Structural Integrity Program,* defines procedures for implementing and sustaining the ASIP, as well as specific organizational responsibilities. The ASIP program is described in the military standard MIL-STD-1530B, and the standard provides technical direction in managing and executing ASIP. [19]

Multiple organizations are involved in the ASIP process at various levels—the Assistant Secretary of the Air Force for Acquisition (SAF/AQ), the engineering directorate in the Aeronautical Systems Center (ASC/EN), system program directors (SPDs), ASIP managers, and lead commands (Table 2).[20] Due to the sheer size of the Air Force's organization, the authorities in ASIP are dispersed geographically. The SPDs and ASIP managers (for aircraft that are no longer being procured) operate at one of three air logistic centers depending on their particular aircraft type or mission, design, or series (MDS), while the corresponding lead command operates elsewhere.

Each SPD is responsible for implementing an ASIP for its fleet and for ensuring that ASIP is continued throughout the fleet's operational life. The ASIP manager establishes the program, tailored to the aircraft type following the direction provided in the MIL-STD-1530B, and carries out the ASIP for their weapon system. The SPD must approve the ASIP. The lead command has the funding and decision authority for the management of multiple fleets within the command, including ASIPs. As a result,

ASIP-Responsible Organizations	Primary ASIP Role	Location
SPDs	Ensure ASIP is implemented throughout MDS life Approve MDS ASIP	Warner-Robins ALC, GA Oklahoma City ALC, OK Ogden ALC, UT
ASIP Managers	Carry out ASIP	Warner-Robins ALC, GA Oklahoma City ALC, OK Ogden ALC, UT
Lead Commands	Fund ASIP	Langley AFB, VA (ACC) Randolph AFB, TX (AETC) Hurlburt Field, FL (AFSOC) Scott AFB, IL (AMC)
ASC/EN	Advise on policies and procedures for technical direction of ASIP Provide ASIP oversight	Wright-Patterson AFB, OH
SAF/AQ	Ensure ASIP is established for all MDS Establish ASIP policies	Washington, DC

Table 2. Roles and Geographic Locations of the Air Force's ASIP-Responsible Organizations

the lead command has a significant influence on ASIP implementation.

ASIP regulatory responsibilities have been assigned to SAF/AQ, ASC/EN, and the SPDs, but ASIP has not been strictly enforced, partly because the ASIP military standard was a guideline that was not enforceable prior to February 2004 (Table 2).[21] These organizations had no regulatory authority over the lead commands' decisions on ASIPs. Additionally, according to the AFPD, the measure of ASIP compliance is the number of Class A and B accidents due to structural failures.[22] This metric can be problematic because it is a lagging indicator of ASIP compliance and thus it is not useful in proactive ASIP management. As a result, compliance with the ASIP policies has been primarily self-managed by the individual SPO.

The Air Force's approach to structural-life management is to prevent structural failures by implementing an effective maintenance plan that inspects for fatigue damage and subsequently conducts timely repairs and modifications for cost-effective life-cycle management. The inspection program monitors fatigue damage (cracks) at critical locations in the aircraft to ensure that the accumulated fatigue damage does not reach the failure threshold (critical crack size) during the service life. Based on the inspection results, the Air Force continues to inspect, repair, or replace the damaged component. The Air Force retires the fleet when continuing to maintain the fleet becomes uneconomical or degrades the fleet's operational effectiveness. For example, rapid growth in the number of cracks in fatigue-critical areas may require multiple major modifications that could significantly impact aircraft availability and sustainment costs.

One of the principal elements in the ASIP process is the development of the Force Structural Maintenance Plan (FSMP), as outlined in MIL-STD-1530B.[23] It provides a schedule for performing maintenance actions (inspection, repair, and modifications) necessary to sustain structural integrity throughout the service life of a fleet (Figure 3). The FSMP is developed using predicted crack growth and critical crack sizes at fracture-critical locations in the aircraft. The FSMP also provides cost estimates of the maintenance actions, whenever possible. Thus the FSMP is a key element in fleet management, as it can be used for maintenance planning, budgetary planning, and retirement planning (based on costs).

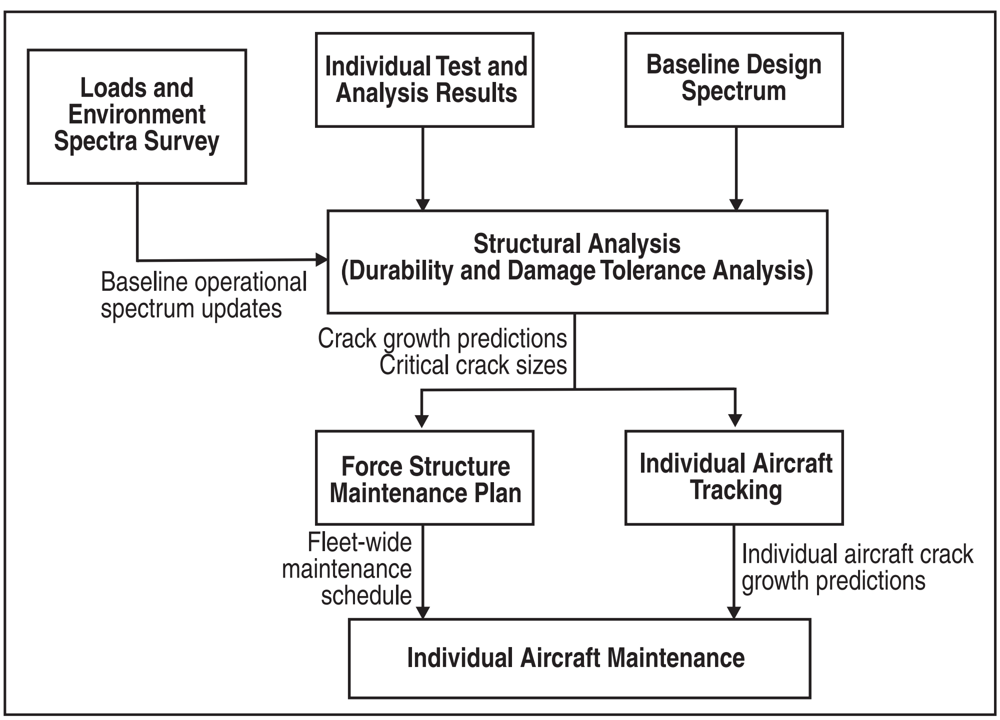


Figure 3. Force Structural Maintenance Plan Development Process, US Air Force

Almost always, the actual usage of the aircraft is different from the assumed design usage. The Air Force tracks aircraft usage to update the FSMP and inspection plans to ensure that fatigue damage in critical locations is detected and repaired in a timely manner. The Air Force tracks aircraft structural usage via two programs: Loads and Environmental Spectra Survey (L/ESS) and Individual Aircraft Tracking (IAT). The L/ESS program determines the fleet-wide baseline operational spectrum. It monitors the actual usage of a fleet sample (15-20 percent) during the first few years of operation. The IAT program tracks individual aircraft by tail number to monitor any variation from the fleet-wide baseline throughout the aircraft's service life. Any significantly different usage would be captured and the individual aircraft maintenance plans updated accordingly. Each SPO is responsible for ensuring that the FSMP is up-to-date and for determining the adequate level of tasks for updating and validating the FSMP, such as collecting adequate L/ESS and IAT data and assessing the structural analysis.

The budgetary process, that is, the program objective memorandum (POM) process, is a formal outlet for the SPD to communicate structural sustainment needs (for example, ASIP tasks, maintenance actions) to the lead command on an annual basis.[24] The lead command reviews what each SPD within its command forwards as the proposed POM inputs; POM inputs include program elements for ASIP as well as other program elements required for sustaining the fleet. The lead command then balances the operational needs (an improved radar) and structural integrity needs (repairing corroded fuel tanks) across multiple fleets to allocate the resources.

The budgetary planning for ASIP can be challenging for the lead command for several reasons. First, the lead command does not have the expertise in ASIP and structural needs. Second, it is difficult to compare the relative needs of the different fleets within a command due to the varying methods and measures of structural condition that each SPO uses for its own MDS. There is no standard metric that conveys the state of the structure. The assessment of the structural condition is left to the judgment of the ASIP manager and the SPD. Finally, communication between the SPD and the lead command regarding ASIP and structural condition is limited. This is because of the limited involvement of the lead command in the ASIP process and the geographic separation between them. Some lead commands have an office of primary responsibility for ASIP to facilitate communications with the SPDs regarding fleet management decisions and ASIP tasks.

Observations

Based on this survey effort, we summarize our observations about the approaches in regulations, communications, and resource management in each service's aircraft structural-life management program in Table 3.

Explicit policy on ASIP provides clarity on ASIP compliance but limits flexibility in structural-life management. Broad policy on ASIP, on the other hand, enables flexibility in ASIP implementation for tailoring, but there is a potential risk of unclear understanding about acceptable ASIP compliance level. The policy should be sufficiently explicit to provide a general guidance on ASIP compliance, but rely on an independent assessment of ASIP compliance on a case-by-case basis to enable tailoring.

Regulations in ASIP can provide checks and balances in structural-life management, enable clear and timely communication, and promote stable and adequate resources for ASIP. Regulations can also lead to complex processes and inefficiencies in ASIP management. Therefore, ASIP regulations should focus on elements of ASIP that are critical to the viability of ASIP and ensure a balance between control and flexibility of ASIP.

Organizational centralization enables standardization in ASIP management and a force-wide view of ASIP compliance and fleets' status, while decentralization enables tailoring to a specific weapon system to achieve a cost-effective ASIP. Centralization of a set of selective ASIP tasks, where standardization is useful, could still allow tailoring of other aspects of ASIP for cost effectiveness.

Regulations, communications, and resource management approaches are highly interdependent and need to complement each other within the context of the program (for example, safe-life versus damage tolerance) to achieve ASIP effectiveness. Operational factors such as the force size may also present certain scalability challenges. For example, the Air Force's large-scale force with a wide range of different aircraft types may pose some challenges in standardizing or centralizing certain aspects of ASIP across the force.

Options for Consideration

The Air Force has opportunities to enhance ASIP by adopting and adapting some of the approaches used by the Navy and the CF. The Air Force may wish to consider the following options.

- Provide clarity in ASIP policy and extend existing processes to enable independent assessment of ASIP compliance
- Formalize key ASIP processes and assign an independent assessment authority to continue enforcement of ASIP and to enhance communications
- Facilitate communications between the lead command and the SPO by establishing a close working relationship

US Navy
- Explicit policy on structural-life management - Central regulatory authority on technical aspect of structural-life management - Standard, quantifiable metric to convey structural condition - Rigorous fatigue life tracking and frequent dissemination of formal fatigue life report - Close working relationship and geographic collocation to facilitate communications - Dedicated funding line for structural-life monitoring
Canadian Forces
- Broad policy based on *airworthiness* concept - Independent, centralized regulatory authority - Regulations to ensure communications and sharing of critical information - Geographic collocation and working relationship to facilitate informal communications - Single funding authority in structural-life management of a designated fleet - Formal planning of resource management via ASIP Master Plan
US Air Force
- Broad policy based on a broad objective - Flexible, decentralized regulatory structure with minimal regulation and oversight - Limited command-wide view of ASIPs and structural conditions - Limited communications with the lead command on ASIP and structural issues - Single funding authority for structural-life management of multiple fleets in a command

Table 3. Summary of Key Characteristics of the US Navy, Canadian Forces, and the US Air Force's Aircraft Structural-Life Management Programs

- Instill standardization for command-wide view
- Dedicate a separate funding line for critical ASIP tasks

Notes

1. Raymond A. Pyles, *Aging Aircraft: USAF Workload and Material Consumption Life-Cycle Patterns*, Santa Monica, California: RAND Corporation, MR-1641-AF, 2003, 1-2.
2. *Ibid.*
3. National Research Council, Committee on Aging of U.S. Air Force Aircraft, National Materials Advisory Board, Commission on Engineering and Technical Systems, *Aging of U.S. Air Force Aircraft - Final Report*, NMAB-488-2, Washington, DC: National Academy Press, 1997, 20-21.
4. USAF Structural Integrity Program Conference 2003, Savannah, GA, December 03.
5. National Research Council, 46.
6. The research also does not include the modified commercial aircraft in the USAF and the USN that were designed to meet the FAA requirements because these aircraft may follow FAA maintenance requirements and other FAA regulations that differ from each service's own structural-life management program.
7. For additional details on fatigue, see, David Broek, *The Practical Use of Fracture Mechanics*, Boston: Kluwer Academic Publishers, 1988; Alten F. Grandt, Jr., *Fundamentals of Structural Integrity: Damage Tolerant Design and Nondestructive Evaluation*, New York, New York: John Wiley and Sons Inc., 2003.
8. J.P. Gallagher, F.J. Giessler, A.P. Berens, and R.M. Eagle, Jr., *USAF Damage Tolerant Design Handbook: Guidelines for the Analysis and Design of Damage Tolerant Aircraft Structures*, AFWAL-TR-3073, Wright Patterson Air Force Base, Ohio, 1984.
9. "United States Navy Fact File," [Online] Available: http://www.chinfo.navy.mil/navpalib/factfile/ffiletop.html.
10. NAVAIRINST 13120.1, *Fixed Wing Aircraft Structural Life Limits,* 20 October 97.
11. The only engineering staff that is detached from the Patuxent River staff is the Fleet Support Team (FST) engineers located at the various depots. The PMAs are not a part of the NAVAIR chain of command. They maintain their statutory lines of authority reporting to the Program Executive Officers (PEOs).
12. The FLE is the complement of fatigue life remaining, that is, FLE of 100 percent is equal to 0 percent fatigue life remaining.
13. For example, the P-3C SLAP spanned 5 years. See, Bharat M. Shah, "P-3C Service Life Management," *Proceedings of 2004 USAF ASIP Conference*, December, 2004.
14. "General Information," [Online] Available: http://www.airforce.forces.gc.ca/today5_e.asp.
15. As a result of adopting the damage tolerance approach, the CF aircraft are being modified to enable inspection of critical areas. Because the safe-life approach does not require inspection for crack growth, these aircraft were not initially designed to allow access to critical locations for inspection.
16. Canada Department of National Defence, *Technical Airworthiness Manual*, October, 2003.
17. CF-18 and CP-140 are the CF's version of the USN's F-18 and the USN's P-3, respectively.
18. "USAF Almanac 2004," *Air Force Magazine: Journal of the Air Force Association*, May 2004, Vol 87, No.5 [Online] Available: http://www.afa.org/magazine/May2004/default.asp.
19. The Air Force released MIL-STD-1530C in November, 2005, as this article was being prepared for publication. These changes do not significantly affect our findings.
20. AFI 63-1001, *Aircraft Structural Integrity Program*, 18 April 02.
21. AFMC has delegated ASC/EN as the AFMC Office of Primary Responsibility for ASIP, in accordance with AFI 63-1001, AFMC Supplement 1, April 2003.
22. AFPD 63-10, *Aircraft Structural Integrity*, 1 November 97.
23. MIL-STD-1530B, *Aircraft Structural Integrity Program*, 20, February 04.
24. The POM process is a part of the programming phase of the DoD budget process, where each DoD component develops a POM and submits to the Office of the Secretary of Defense for a review. The POM entails a six-year funding plan to accomplish overall program goals and milestones.

Dr Yool Kim is an engineer at Rand. Colonel Stephen Sheehy, USAF, is the Director, Support Services, DCS Plans and Programs, Headquarters Air Force. Commander Darryl Lenhardt, USN, is the EA-18G Project Officer and Advanced Anti-Radiation Guided Missile Test & Evaluation IPT lead/ Anti-Radiation Missile Class Desk, Anti-Radiation Missile Program Office, Naval Air Warfare Center Weapons Division, China Lake, California. At the time of this study, Colonel Sheehy and Commander Lenhardt were military fellows at RAND.

Lessons from the First Deployment of Expeditionary Airpower

The lens of history speaks to many of the issues that are significant in today's expeditionary airpower environment. Particularly relevant are the lessons learned during first deployment of expeditionary airpower by the Royal Flying Corps during WW I. These include the following.

- The use of airpower is an expensive proposition.
- Maintaining aircraft away from home station demands considerable resources.
- Attrition from active operations is often very high.
- Effective support demands the ready availability of spares.
- Transport and protecting the transportation system is critical.
- Preserving mobility (the ability to redeploy quickly) is a constant battle.
- The supply system must be adequate in scope with a margin in capacity to meet unplanned events.
- The essential *lubricant* is skilled manpower.

Group Captain Peter Dye, RAF, *By It, Move It, Sustain It*

Over the next several years the US Department of Defense has some very hard decisions to make regarding strategic airlift. If funding is not available to meet 54.5 MTM/D or more with conventional airlift, either sacrifices in capability must be made or an alternative will have to be found.

logistics history

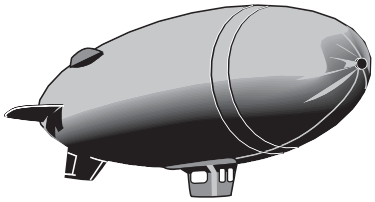
Back to the Future: Airships and the Coming Revolution in Strategic Airlift

The last major study of US airlift requirements, *Mobility Requirements Study 2005*, concluded the United States requires an airlift fleet capable of transporting 54.5 million ton-miles per day. Recent developments indicate when the latest mobility capability study is released in May 2005 the requirement will be even higher, perhaps up to 60 MTM/D. According to General John Handy, commander of AMC and USTRANSCOM, even meeting the lower requirement requires a C-17 fleet of 222 aircraft, 42 more than the 180 currently under contract. This article proposes an alternative aircraft, a hybrid aircraft, half airship/half airplane, which would cost about the same as a C-17 to acquire but would potentially be three times as productive and cost one-half to one-third as much to operate per ton-mile.

Lessons from History | Colonel Walter O. Gordon, USAFR
Colonel Chuck Holland, USAF, Retired

airships and the revolution in strategic airlift

Back to the Future



Article Acronyms

AAA – Antiaircraft Artillery
ACLS – Air Cushion Landing System
AMC – Air Mobility Command
ATG – Advanced Technology Group
CBD – Commerce Business Daily
DARPA – Defense Advanced Research Projects Agency
FOB – Forward Operating Base
HA – Hybrid Aircraft
LAIRCM – Large Aircraft Infrared Countermeasures
LZ – Luftschiff
MTM/D – Million Ton-Miles per Day
MANPAD – Man-Portable Air Defense
SBCT – Stryker Brigade Combat Team
SPOD – Sea Port of Debarkation
USTRANSCOM – United States Transportation Command

The Requirement

The last major study of US airlift requirements, *Mobility Requirements Study 2005* concluded the United States requires an airlift fleet capable of transporting 54.5 million ton-miles per day (MTM/D). Recent developments indicate the requirement will be even higher, perhaps up to 60 MTM/D. According to General John Handy, commander of Air Mobility Command (AMC) and Transportation Command, even meeting the lower requirement requires a C-17 fleet of 222 aircraft, 42 more than the 180 currently under contract.[1] With the Air Force fighting the possible cancellation of the C-130J as well as a significant cutback in the number of F/A-22s, the purchase of 52 more C-17s seems unlikely, much less the number required to meet 60 MTM/D.

Is the C-17 the best way to overcome the airlift shortfall? This article proposes an alternative aircraft—a hybrid aircraft, costing about the same as a C-17, but potentially three times as productive and costing one-half to one-third as much to operate per ton-mile.

An airship obviously has significantly different operating characteristics than an aircraft. Some operating characteristics are better, some are not, and some are just different. Those characteristics will be discussed in this article, but the bottom line is that an airship is probably a viable and affordable alternative to buying additional C-17s and should be considered for filling the airlift gap.

Airship 101- A Brief History

The Flight of the *Luftschiff Zeppelin 59*

In 1917 a German aircraft departed Bulgaria on a 3,600 nautical-mile flight carrying 30,000 pounds of medical supplies and ammunition for a beleaguered army unit in Africa. When it landed 95 hours later it still had 64 hours of fuel remaining—enough to have flown to San Francisco had it taken a great circle route west instead of flying south. Nonstop flights from Bulgaria to San Francisco carrying that large a payload could not have been accomplished by a B-29 thirty years later. In 1917, it was closer to the realm of science fiction.[2]

What type of aircraft was this and how was it possible in 1917? It was the German *Luftschiff* Zeppelin *59 (LZ 59)*, a rigid airship. During the flight most of the weight of the ship was held aloft by buoyant lift, the difference in weight between the air displaced by its gas envelope and the hydrogen contained within. As a result, all the engines of the Zeppelin had to do was overcome the drag of the vessel as it passed through the air. The engines on a conventional aircraft must do that as well, but must also overcome the additional drag from the wings lifting the weight of the aircraft.

Graf Zeppelin

Twelve years later, in August 1929, the German airship *Graf Zeppelin* flew around the world in four stops carrying twenty passengers and forty-one crew. The longest leg

An airship obviously has significantly different operating characteristics than an aircraft. Some operating characteristics are better, some are not, and some are just different.

was a nonstop flight between Friedrichshafen, Germany and Tokyo, a distance of over 7,000 miles covered in 100 hours. Not only was a flight like this unthinkable by an airplane in 1929, the passengers made the flight in accommodations unavailable to the commercial air traveler even today (see Figure 1).

The spacious dining room of the *Graf Zeppelin* makes another point about airships. Because the gas envelope is necessarily many times larger than the fuselage of an airplane of comparable gross weight, they tend to have much more volume available for passengers and cargo. It is much more difficult to *bulk-out* an airship than an aircraft.

US Navy Airship Operations

From 1923 to 1935 the US Navy operated a total of four rigid airships, *Shenandoah, Los Angeles, Akron, and Macon.* The loss of three of them to accidents—only *Los Angeles* retired without mishap—coupled with the loss of the *Hindenburg* several years later, sounded the death knell for large airship operations. Looking at the losses of the individual ships, however, one sees that it was not as bad as a simple 75 percent hull loss rate might indicate.

Shenandoah flew 740 hours before being lost in a severe thunderstorm. *Los Angeles* retired with 4,181 hours. *Akron* crashed at sea in a storm due to a faulty altimeter setting with 1,695 hours, and *Macon* ditched at sea with 1,798 hours after her vertical stabilizer was ripped off by clear air turbulence.[3]

Compared to airplanes from the same period these are probably not bad numbers, and when you consider these four rigid airships were the first (and last) the US ever operated, in some ways their record is remarkable—undoubtedly, far better than the first four airplanes. But these losses, coupled with significant advances in airplane technology, enabled aircraft to surpass airships in most areas of operation. This ended operation of the large airship in the United States and the world, at least until today.

Airship Basics

In order to understand the capabilities and limitations of airships certain basic principles must be understood.

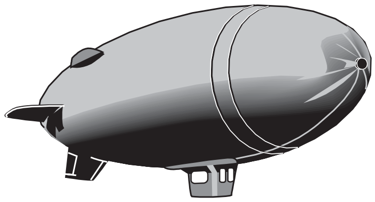
Aerostatic Versus Aerodynamic Lift

Unlike an airplane in which lift is generated aerodynamically, the lift required for an airship to leave the ground is produced aerostatically by the buoyancy of the lifting gas in the surrounding ocean of air. A very significant difference between the two is aerodynamic lift costs horsepower and fuel in the form of induced drag, which is roughly proportional to the lift required. This is in addition to parasitic drag—so-called because it does not provide anything useful, like lift—which varies with the square of the velocity of the aircraft and explains why higher speeds require significantly more thrust.

Aerostatic lift, on the other hand, has no induced drag component. The vehicle is lifted by the buoyancy of the lifting gas and all the engines must do is overcome parasitic drag to move the vehicle through the air. This explains the remarkable performance of airships such as the LZ 59 and *Graf Zeppelin* given the limited performance of the internal combustion engines available at the time. The engines only had to move the airship, not lift it, and since the airships were relatively slow even the parasitic drag component was small.

The two lifting gases historically used in airships are hydrogen and helium. Hydrogen is less dense so it has slightly more lift, about 70 pounds per 1000 cubic

Figure 1. *Graf Zeppelin* Dining Room



These requirements are written for an airship. No known or planned airplane can meet the combination of cargo weight, unrefueled range, and ability to land at a short, unimproved site.

feet of gas versus 65 for helium. It is also considerably less expensive. Because hydrogen is highly flammable all contemporary airships use helium. The reason the German airships of the twenties and thirties used hydrogen is because at the time the United States had the only useful supply of helium in the world and was unwilling to sell it to Germany because it was considered a war resource. American airships of the same period all used helium.

Rigid versus Nonrigid Airships

From a structural viewpoint, airships may be constructed in two ways, rigid and nonrigid. In a nonrigid airship, which is the only type constructed today, the rigidity of the ship is provided by slight pressurization of the lifting gas. The Goodyear Blimp, or any other blimp for that matter, is a nonrigid airship.

Akron, *Macon*, *Hindenburg*, and all the other great airships of the twenties and thirties were rigid airships, or dirigibles, in which the rigidity of the ship is provided by a vast aluminum hull structure completely filling the outer envelope. The lifting gas was then contained within a number of individual gas cells contained sequentially front-to-back within the hull structure. The gas cells themselves had virtually no pressurization. They simply floated against the top and sides of the hull structure to keep the airship aloft.

Rigid airships are much more expensive to produce than the nonrigid variety primarily because of the complexity of the aluminum hull structure. In a nonrigid airship the hull structure consists of both the outer envelope of the ship—which serves double duty as the gas envelope—and the lifting gas itself, which is slightly pressurized to between 1/4 and 1/2 pound per square inch to give the envelope rigidity. To paraphrase a contemporary airship design engineer, "I like helium because it is a great structural material that also happens to lift itself plus more. It allows us to build these hugely large vehicles relatively inexpensively and as a bonus they don't weigh nearly as much as they would if constructed conventionally."[4]

The biggest drawback of a nonrigid is they are limited in size by the strength of the fabric used in the envelope. Even though they are only slightly pressurized, the larger a nonrigid airship gets the greater the stress in the fabric even if the internal pressure remains constant. In the twenties and thirties the state of the art of fabric technology only allowed the construction of small blimps, hence all large airships were rigid out of necessity. Almost all airships proposed for construction today are nonrigid and the balance of this article will refer only to nonrigid airships unless specifically stated otherwise.

Pressure Height

When an airship climbs the lifting gas within it expands as atmospheric pressure decreases. As this occurs the lifting gas must be allowed to expand for two reasons. First, to try to contain it under increasing pressure puts unnecessary stress on the envelope. Though an airship may appear to be highly pressurized, the pressure inside the envelope is maintained only slightly above ambient (less than 1 pound per square inch) to maintain its structural integrity. Second, because the pressure and density of the atmosphere decreases with altitude as the airship climbs, the lifting gas must continue to provide the same amount of buoyant lift and must be allowed to expand to displace additional ambient air.

In a nonrigid airship this is accomplished by incorporating separate, smaller envelopes called ballonets within the main envelope. The ballonets are filled with ambient air and expand and contract opposite the lifting gas (see Figure 2). Before takeoff the ballonets are filled with air and the rest of the envelope with helium. As the airship rises and the helium expands within the main envelope, air in the ballonets is released into the atmosphere and the ballonets contract. The *pressure height* of the airship, which is generally the maximum operational ceiling, is the altitude at which the ballonets are completely emptied of air and helium fills the main envelope. When the airship descends and the helium contracts the ballonets are refilled with atmospheric air to compensate for the shrinking helium and maintain the same relative pressure and total volume of gas within the main envelope.

The design pressure height of an airship is important because it determines the proportion of total envelope volume allocated to air in the ballonets—more air means greater pressure height, but it also means less of the main envelope is allocated to helium at takeoff, which means less lift. An airship that is going to take off at sea level and climb to 10,000 feet en route must have approximately 30 percent of its total envelope volume taken by air in the ballonets at take off to allow room for the expansion of helium during the climb. This means the amount of helium available for lift is only 70 percent of the total envelope volume. If that same airship only had to climb to 3,000 feet, however, the ballonets need only be filled to 10 percent of the total volume so 90 percent could be filled with helium. All other things being equal, this means an airship that had to climb to 3,000 feet on a mission could take off with 28 percent more payload by weight than an identical airship that had to climb to 10,000 feet, the difference the 90 percent helium fill versus 70 percent fill.

This tradeoff must be considered during route planning for an airship, as it could be more efficient to deviate several hundred miles on a transcontinental mission to avoid an 8,000-foot mountain range instead of climbing over it. The additional payload available due to a lower pressure height would probably more than make up for the fuel required by the slightly longer route.

If ballonets are placed fore and aft in the vehicle as illustrated in Figure 2, they may also be used for trimming the aircraft in lieu of aerodynamic trim. Pumping more air into a front ballonet and less out of a rear one while keeping the total volume constant is essentially a transfer of ballast (the air), which shifts the center of gravity of the airship forward. This is more efficient than using aerodynamic trim which increases induced drag that, in turn, increases fuel consumption.

Buoyancy Compensation

Another aspect of airship operations that is not technically obvious is buoyancy compensation. When an airship takes off with neutral buoyancy the aerostatic lift produced by the helium is equal to the total weight of the vehicle—the combined weight of the structure, payload, and fuel. As fuel is burned en route, however, the total weight of the airship decreases but the aerostatic lift remains the same. If nothing is done, over time the ship will gain significant positive buoyancy. As this is undesirable from both a control and structural viewpoint, the airship must have a mechanism for buoyancy compensation.

Hydrogen-filled airships such as the *Graf Zeppelin* and *Hindenburg* simply vented excess hydrogen into the atmosphere to compensate for the weight of fuel burned. This was an acceptable solution because hydrogen was both inexpensive and easily generated wherever the ships were scheduled to land and refuel. Not so for helium, however, which is considerably more expensive and cannot be generated locally. It must be shipped in heavy steel cylinders from where it was originally mined or subsequently stored. Helium-filled airships such as the *Akron* and *Macon* were constructed with an apparatus on the engine exhaust to condense and recover the water it contained. The water was then stored to compensate for the weight of fuel burned. While a seemingly elegant solution to the en route buoyancy compensation problem, water recovery apparatus was heavy, at least initially unreliable, and the condensers mounted on the skin of the ship added drag. While the equipment improved over time, "the water recovery problem as a whole remained the *bête noire* of the helium-inflated rigid airship."[5]

The other aspect of the buoyancy compensation problem occurs when cargo is offloaded at destination. If an airship arrives at a destination with neutral buoyancy and offloads 30 tons of cargo, it immediately has 30 tons of excess lift. For an airship in commercial operations this is addressed by onloading equivalent ballast, either outbound cargo, water, or both, as the inbound cargo is removed. It can be problematic for a military airship however, as there is often no outbound cargo during a buildup at a forward operating base, and lately many of the deployed operations of the US military have been to regions where large quantities of water are not readily available.

Hybrid Aircraft

Addressing the destination buoyancy compensation problem when ballast is not available is one of the main reasons driving examination of the hybrid aircraft (HA). A hybrid aircraft is an airship in which significant lift is provided both aerostatically and aerodynamically. While all airships generate and make use of a small amount of aerodynamic lift, it is generally only to address minor buoyancy issues en route. The cylindrical fuselage of a conventional airship is optimized for volumetric efficiency of the lifting gas and low parasitic drag, not to generate lift, and

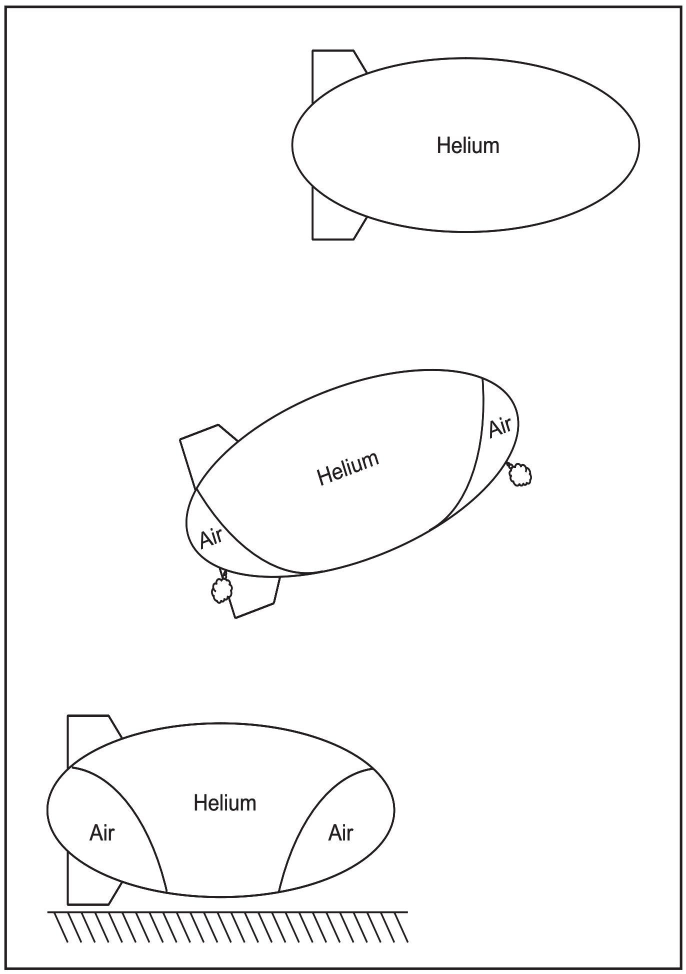
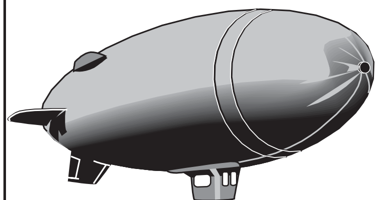


Figure 2. Ballonets at Takeoff, Climb, and Pressure Height



Unlike an airplane in which lift is generated aerodynamically, the lift required for an airship to leave the ground is produced aerostatically by the buoyancy of the lifting gas in the surrounding ocean of air.

they typically take off and land with close to neutral buoyancy. A true hybrid aircraft is designed to take off and land heavier than air, but makes use of aerostatic lift to give part of the weight of the vehicle a *free ride*.

The elegance of a hybrid aircraft is that it may be designed so an apportionment of aerostatic and aerodynamic lift can completely address the buoyancy compensation problem. Assume an airship in which its gross weight consists of 50 percent structure, 25 percent payload, and 25 percent fuel. As a hybrid aircraft, it would be designed so at takeoff half the lift would be provided aerostatically, lifting the fixed structure, and half aerodynamically, lifting the fuel and payload. En route, as fuel is burned, the angle of attack of the airship (essentially the degree to which it is flying nose up) is reduced proportionally so less aerodynamic lift is generated and total lift remains the same as the gross weight of the vehicle (now reduced for fuel burned). When the HA arrives at destination with a small amount of fuel remaining and the cargo is unloaded, it will still be slightly heavy and not require ballast because the aerostatic lift is still only lifting the structure.

With this added flexibility comes several penalties. First, because it always operates heavier-than-air (think of it as an airplane with subsidized lift), it cannot take off or land vertically or hover. Second, because of the induced drag generated by aerodynamic lift, a hybrid aircraft is less efficient than a pure airship. However, it can still be considerably more efficient than an airplane.

The 21st Century Airship

Background

In January 2004, the Defense Advanced Research Projects Agency (DARPA) published a request for information in the Commerce Business Daily (CBD) for a "Heavy Lift Air Vehicle" capable of carrying "500 tons or more over intercontinental distances."[6] A draft program solicitation released in April contained additional information:

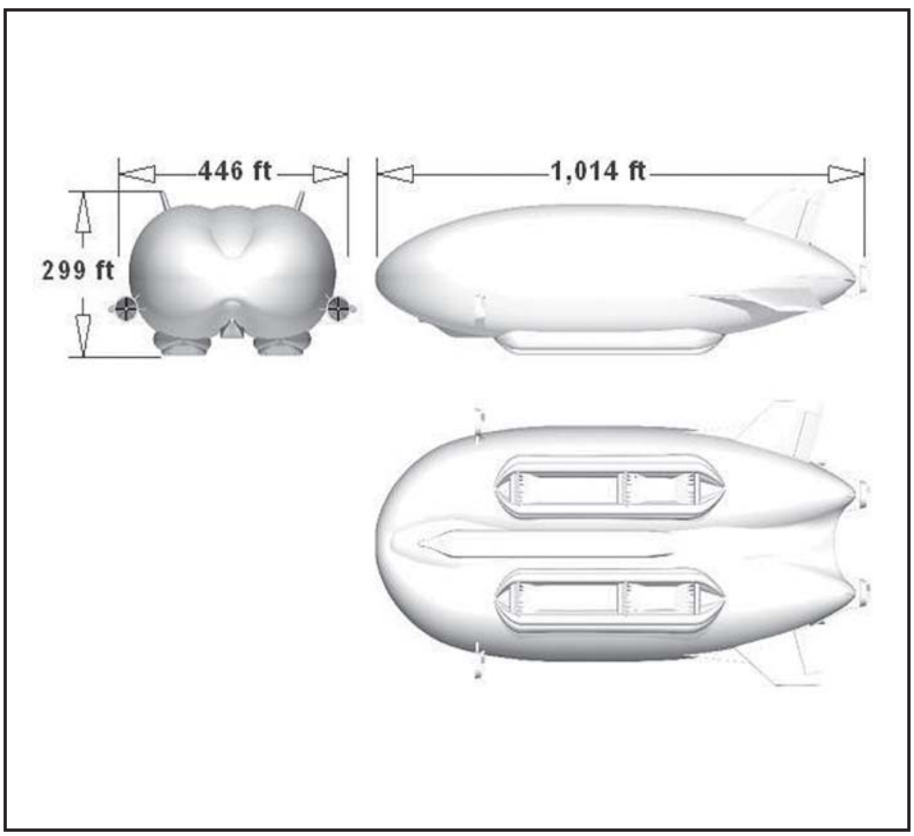


Figure 3. SkyCat 1000

> The baseline mission for WALRUS is to transport personnel and equipment from "Origin to Destination." This mission anticipates loading at a continental US home base and flying strategic distances nonstop to deploy military units in a theater of operations in a fit-to-fight condition. Anticipating local air superiority in the area of landing operations with ground defenses suppressed, WALRUS will land vertically or short rolling at an unimproved site. It will have sufficient fuel and control to take off empty (no external ballast to offset offloaded payload will be required) and to depart the area of hostilities before refueling for return to base.[7]

Strategic distances are specified elsewhere in the document to be up to 6,000 miles.

These requirements are written for an airship. No known or planned airplane can meet the combination of cargo weight, unrefueled range, and ability to land at a short, unimproved site.

A very large conventional airship using buoyant lift could meet all three of those requirements but would require ballast at destination to offset the weight of the offloaded cargo, which is prohibited in the cited paragraph. An alternative to ballast would be to vent helium to reduce lift at an amount equal to the cargo weight. For 500 tons of cargo this would be over a million dollars worth of helium, not something that could be done for normal operations.

A hybrid aircraft would meet these requirements by using dynamic lift to carry the weight of cargo so when it is offloaded it would be neutrally buoyant or close to it, not 500 tons light.

The Hybrid Aircraft

Several firms, including Lockheed Martin and Advanced Technologies Group (ATG), a United Kingdom-based airship manufacturer, have proposed pressurized, nonrigid hybrid aircraft in which the shape of the hull is maintained by gas pressure within the envelope. The SkyCat 1000, a 1000-ton payload version, is illustrated in Figure 3. A 500-ton class vehicle would be slightly smaller, but still very large, at approximately 850 feet long, 375 feet wide, and 250 feet high. This may seem large, but it is not much longer than the Akron which was 785 feet long, though it is considerably wider and taller. The Akron had a circular cross-section 150 feet in diameter.

The balance of this article will refer primarily to a 500-ton payload class HA with characteristics derived from several industry sources unless otherwise noted.

Physical Characteristics and Performance

Computed characteristics and performance of a notional 500-ton vehicle are presented in Table 1. The vehicle is designed with a number of unique features to meet the Walrus requirement.

Air Cushion Landing System

The proposed vehicle uses an air cushion landing system (ACLS) instead of conventional wheeled landing gear (see Figure 4). When operating in a reverse, or suction, mode, the ACLS serves to eliminate ground mooring equipment by holding the aircraft firmly against the ground.

A significant advantage of the ACLS is it works equally well on land or water, making the vehicle amphibious. Missions could be flown to ships at sea, delivering or picking up cargo that cannot wait for another ship. The vehicle may also operate like a flying boat, taking off and landing from the water and then taxiing to the shore for onload and offload. If the gradient is shallow enough it could even taxi up onto a beach, removing the vehicle completely from the water much like an air cushion landing craft. On land, the ACLS will also work on unimproved surfaces such as flat fields or surfaces covered with ice or snow.[8]

A drawback of the ACLS when compared with a conventional landing gear is that it cannot be used to stop the aircraft, as is the case with wheel brakes. On nonabrasive surfaces such as ice or snow, or on other surfaces in an emergency situation, it may be possible to turn off the outflow of air to lower the skirt to the ground, bringing the vehicle to a stop faster. In normal operations, however, reverse thrust would be used to bring the vehicle to a stop.

In the ATG concept, when the aircraft is parked with little or no wind and it is heavy, the skirt is inflated (the skirt is always inflated on the ground) but outflow from within the ACLS skirt is turned off and the vehicle rests with the skirt on the ground. In higher wind conditions that might cause the vehicle to drag or if the vehicle is light, air is withdrawn from within the skirt, creating a suction to hold the vehicle down.[9] Lockheed's concept is similar, except they feel suction should be continuously on whenever the vehicle is on the ground as it is too susceptible to being moved by a sudden gust.[10]

In flight it may be possible for the ACLS skirt to be deflated and retracted against the fuselage to reduce drag.[11]

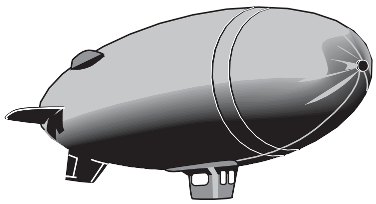
Propulsion

The HA is propelled by four gimbaled propeller units (visible in Figure 3). Two are located at the back of the vehicle and one is located on each side toward the front. ATG intends to use four external turboprop engines of the type planned for the A400M airlifter. Lockheed's propulsion system may be similar, though they are also considering using diesel or turbine power generation units centrally located in the vehicle providing DC power to electric motors in thrust pods turning propellers on the exterior. They anticipate several core power units for both redundancy and efficiency. If one fails all four thrust pods will continue to operate. Additionally, when the vehicle is lighter after some fuel has burned off en route, less power is required and one power unit may be shut down intentionally to conserve fuel. The centrally-located power generation scheme offers several other

Characteristics	Performance
Length	850 feet*
Width	375 feet*
*Height	250 feet*
Displacement of envelope	24 million cubic feet*
Volume of helium at sea level	14 million cubic feet*
Cruising speed	80-110 knots
Range	6,000 nautical miles
Ceiling	9,000 feet
Takeoff distance, full load	8,000 feet
Landing distance at FOB	1,500 feet
Cargo weight	500 tons
Fuel weight	300 tons*
Thrust units	Two aft, two side

*** Will vary with specific design**

Table 1. Characteristics and Performance of 500-Ton Payload HA



In order to meet the short-field landing requirement, the HA is capable of landing and taking off at extremely low speeds on the order of 25-35 knots.

advantages. If future technology provides a more efficient means of generating electricity, such as fuel cells or nuclear power, only the power units need be replaced, the rest of the propulsion system will remain unchanged.

A system to recover water from engine exhaust could be incorporated to provide buoyancy compensation for the fuel burned en route. Such a system would be simpler for centrally-located power units than separate engines mounted on the thrust pods.

Centrally locating the power also makes it easier to manage the heat generated, whether to superheat the helium for additional lift or to reduce the infrared signature of the exhaust to reduce vulnerability to man-portable air defense (MANPAD) systems. Certainly the limited heat generated by the electric motors in the thrust pods will be easier to dissipate than the exhaust of an externally-mounted engine.

Last, a power generation system that has a greater installed weight than a conventional system but uses fuel more efficiently, has the potential to ameliorate part of the buoyancy compensation problem. For example, if externally-located turboprops have an installed weight of 50 tons but burn 200 tons of fuel en route, they generate 200 tons of buoyancy that must be compensated for with ballast or aerodynamic lift. If a centrally-located turbo diesel power plant weighs 150 tons but only burns 100 tons of fuel en route, it only generates a 100-ton buoyancy compensation problem (and hence a more efficient vehicle if it is accounted for by aerodynamic lift) even though the total weight of the propulsion system plus fuel is the same as the turboprop installation.

Thrust Vector Control

In order to meet the short-field landing requirement, the HA is capable of landing and taking off at extremely low speeds on the order of 25-35 knots. At these speeds there is not enough dynamic pressure over reasonably sized aerodynamic control surfaces to adequately control the vehicle, so it is done with thrust vector control of the thrust pods. The side propeller units gimbal ±90 degrees vertically for pitch control, while the rear units gimbal 60 degrees in all directions for pitch and yaw control.

Risk Areas

While the original DARPA CBD announcement did mention the possible investigation of some fairly esoteric technologies, they are not required for the hybrid design proposed in this article. Certain technologies are, however, of medium risk.

Envelope Fabric

As the size of a nonrigid airship increases, so does the stress in the fabric. The material required to produce fabric for a 500-ton vehicle is on the borderline of what has been tested in the laboratory but has not yet been made into a flightworthy fabric. This is considered to be a medium risk area. The joint technology used to join the cut pieces of fabric together to make the large envelope also must be proven at the higher stress level associated with a larger vehicle.[12]

Air Cushion Landing System

The ACLS is going to be an active structure, operating continuously while the vehicle is on the ground, either in the hover mode if the vehicle is taxiing or taking off, or the suction mode if it is stationary. Since the ACLS serves as the airship's mooring system, the worst-case consequences of it failing are quite serious. Imagine a 350-ton (or more) vehicle the size of an aircraft carrier blowing down the block.

The vulnerability of airships to surface winds is illustrated in Figure 5. A series of photographs showing the *Los Angeles* (all 75 tons and 650 feet of her) swinging over the mooring mast when a wind and temperature shift raised the tail of the ship before the crew could compensate. It is worth noting that even though the incident appears very dramatic, the damage to the ship was incidental and it could have been flown

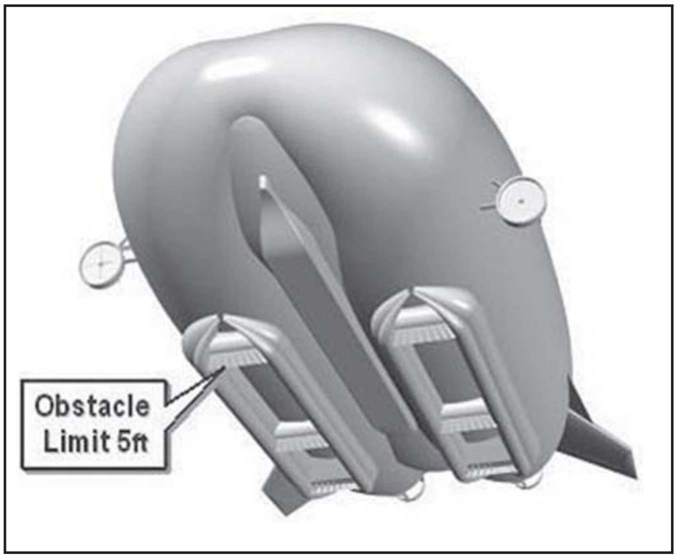


Figure 4. SkyCat Air Cushion Landing System

away immediately after, if necessary.[13]

Lockheed feels the ACLS is also a medium risk item; not because of any new technology required, but because nothing like it has been built before for this application and a significant amount of new engineering is required.[14]

Flight Control System

The HA must have a digital flight control system both to eliminate excessively long cable runs and also to reduce the workload for the pilot of what would be a sluggish, difficult-to-control aircraft. The use of thrust vector control combined with conventional control surfaces, both in flight and for maneuver on the ground, would also increase the workload of the pilot, probably excessively so, if not managed by a computer.[15]

Operational Considerations

Runway Requirements

The HA is designed to take off and land directly into the wind, so it does not have crosswind limits. It does require rectangular or circular landing zones. The takeoff area required for a fully loaded HA with 500 tons of cargo and 300 tons of fuel is estimated to be 8,000 feet. An 8,000-foot concrete circle or rectangle may seem like a lot, but recall that because of the capabilities of the ACLS, operation from a runway is not required. The vehicles will typically operate from the water if leaving from a sea port of debarkation (SPOD) or from a drop zone if leaving from an Army base, a conventional aerial port of debarkation would normally not be used.

The landing area required at destination when most of the fuel is burned off is estimated to be 1,500 feet. Again, circular or rectangular landing areas are required so the aircraft can land and take off into the wind.

Winds Aloft

The relatively low true airspeed of a hybrid aircraft makes it especially vulnerable to increased transit time due to headwinds, so much so that significant deviation from the most direct route in pursuit of tailwinds can have a large benefit. For example, a 100-knot HA flying into an average 20-knot headwind would take 58 hours to fly 4,600 miles along the ground, the great circle distance from the West Coast of the US to Korea. If by deviating 1,000 miles around circulating weather patterns the 20-knot headwind is turned into an average 20-knot tailwind, the trip would only take 47 hours, a half day less of transit with significant fuel savings as well. In fact, because the HA is capable of such significant deviation to take advantage of tailwinds and mitigate the effect of headwinds, the presence of real-world wind on a given route would not increase transit time more than 5 percent and almost always results in lower total time for a round-trip flight.[16]

Terminal Weather

The Sky Cat 1000 report gives the ceiling and visibility requirements for the vehicle as a 200-foot ceiling and zero visibility, or "0/0 for military fields with precision approach radar capability."[17] While these figures may be correct, one needs to keep in mind that the landing zones (and water areas for SPODs) from which the vehicle is going to operate will often not have instrument approaches, so the vehicle will not always be able to operate in such poor weather. Even if self-contained Global Positioning System/inertial navigation system approaches are constructed on the fly for a tactical landing zone they will still not have received either the level of scrutiny with respect to obstacles in the area or the flight inspection of a conventional approach.

Weather Hazards

Like any aircraft, the HA would seek to avoid thunderstorms, and equipped with an onboard weather radar and real-time weather information would be able to do so.[18] Studies anticipate the aircraft would be damaged, but not brought down should it be struck by lightning. Several means of adding conductive material to the envelope to further ameliorate the effects of a lightning strike have been discussed but would add cost and weight to the vehicle that are not included in the estimates presented in this report.[19]

In-flight icing would be addressed by a number of anti-icing and deicing measures similar to conventional aircraft. Ice accumulation while the aircraft is parked on the ground could be a significant problem as the vast area of the envelope means even a thin coating of ice would have significant weight. Conventional deicing by truck would be almost impossible because of the large size of the HA. A mechanism could be designed into the vehicle

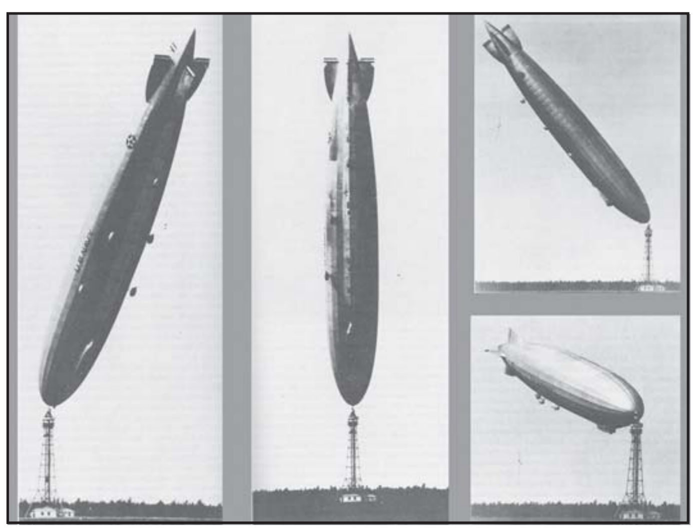
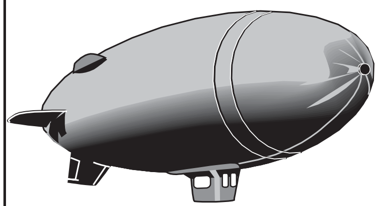


Figure 5. *Los Angeles* on End



A significant advantage of the ACLS is it works equally well on land or water, making the vehicle amphibious.

to disperse anti-icing solution over the envelope but this would have its own set of issues regarding the quantity of fluid required and whether it would have to be recovered because of environmental concerns. It would be simplest if the vehicle was flown away during prolonged icing conditions on the ground.

Snow accumulation while parked is less of a concern than ice because of its reduced weight. The HA could actually take off supporting a thin layer of snow and buildup in excess of that could be prevented by high-speed taxiing.

Ballast

While one of the main reasons for employing a hybrid aircraft is to eliminate the need for buoyancy compensation ballast, the efficiency of the vehicle can be improved if ballast is available when the cargo is offloaded or even earlier in the flight after some of the fuel has been burned off. The reason is simple but probably not intuitive. The amount of aerostatic lift allowed for a particular mission is limited by the requirement for the vehicle to be slightly heavy before departing the forward operating base (FOB) after the cargo is offloaded. When the vehicle is required to operate with no ballast, this lift is equal to the empty weight of the HA plus any remaining fuel at that point. For a 300-ton empty weight HA with 25 tons of fuel remaining that would be 325 tons. As a result, before initial departure from home station the amount of air in the ballonets would have to be adjusted to 325 tons of aerostatic lift even if the total gross weight of the vehicle at the time was several times that with cargo and fuel load. The balance of the lift en route would have to be provided aerodynamically, which is not as efficient.

If ballast may be taken on to offset fuel burned at some point in the mission, however, initial aerostatic lift may be increased to reflect the weight of the ballast, because after the cargo is offloaded at the FOB the ballast is still present to prevent the vehicle from having positive buoyancy. If in this same example the vehicle was able to land on the ocean, prior to coasting in at the destination landmass, and onload 100 tons of ocean water ballast, the aerostatic lift at initial takeoff could be adjusted to 425 tons instead of 325, making for a more efficient flight profile, requiring less fuel overall.

Mission Effectiveness

The bottom line for acquisition of a fleet of hybrid aircraft simply comes down to mission effectiveness and cost. Will it get there soon enough, safely enough, and with enough stuff? Is it more economical to acquire and operate than the competition?

Vulnerability

The first question most people ask when told about using airships for strategic lift is, How vulnerable is it? The answer to that question is, Much less than you would think, but it depends on the situation and what you are comparing it to.

Compared to a waterborne ship, an airship is less vulnerable because over the ocean it is almost always safer to be several thousand feet in the air than on the surface of the water. Threats from mines, torpedoes from submarines or surface vessels, surface-to-surface or air-to-surface anti-ship missiles, suicide speedboats, or boarding by pirates simply do not apply to an airship. Those things that could threaten an airship, such as fighter aircraft or surface vessels armed with surface-to-air missiles or artillery (and the airship could easily detect and avoid or outrun the latter if they were perceived to be a threat), would be just as threatening to surface vessels. So even from a brief qualitative analysis it is readily apparent that only a small subset of the possible threats to surface ships could threaten an airship.

The comparison is a little more complicated when made against other aircraft. Compared to a C-5 or C-17, the probability of kill given a hit by anything except the largest surface-to-air ordinance is lower for an airship than an airplane. Large surface-to-air missiles, such as the SA-6 or SA-10, would probably bring down an airship as they would an airplane, but even then because of its extreme size and lower speed the airship might be able to land under some semblance of control where an airplane would simply come apart.

For simplicity the vulnerable area of an airship may be divided into three categories.

- Envelope
- Fuselage
- Propulsion units

Should the envelope be hit by antiaircraft artillery (AAA) projectiles that do not detonate but simply make holes, the effect would hardly be noticeable. Because of the extremely low pressure of the lifting gas, the rate of exchange between helium and ambient air across even hundreds of 23 mm holes would not prevent the airship from completing its mission and flying to a safe location to be repaired, if not even back to its home base. Even if a MANPAD were to detonate against the envelope instead of punching a hole in it, the resulting hole would be much more significant, but it would still take hours, not minutes, to bring the airship down. And it would land, not crash.[20]

If the fuselage were struck by AAA it would certainly detonate, but industry designers believe they could allocate sufficient weight to incorporate Kevlar armor under the entire fuselage designed to protect it up to direct hits from 23 mm AAA.

If a MANPAD were to strike one of the four propulsion units it would probably destroy it. As with a four-engine airplane, however, the HA is capable of maintaining flight with only three propulsion units. In fact, only two are necessary in most circumstances as long as they are on opposite sides. The likelihood of a MANPAD striking the propulsion unit is open to question, however, if the HA has a central power generation system in which power is generated in the center of the fuselage and routed to electric motors in each propulsion unit. The electric motors would have a much lower infrared signature than a turbine engine, and the heat from the central generation unit would either be vented out the top of the airship or used to heat the lifting gas several degrees for extra lift. The HA would also be able to be fitted with large aircraft infrared countermeasures that would further reduce its vulnerability to MANPADs.

The above discussion applies to the probability of a kill given a hit. However, the vulnerability of an airship to a hit is unquestionably higher than an airplane. While a C-5 or C-17 cruises above all except the largest surface-to-air threats and is only exposed to smaller ones in the terminal environment, an airship cruising at 9,000 feet over land is exposed to everything, except small arms. This is the long pole in military airship vulnerability and except for the protective measures outlined above there is no getting around it. If there is a threat along the route of flight, efforts would have to be taken to ameliorate it as much as possible by flying at night and avoiding threats to the greatest extent possible. This effort would be aided by the fact that unlike a large airplane, which has to head for a runway near which threats could be placed, the airship can land anywhere there is a 1,500 foot diameter circle of unobstructed ground, significantly complicating the enemy's targeting problem.

Notional Scenario

The results of an industry study of the deployment of a Stryker brigade combat team (SBCT) from Fort Lewis, Washington, to Kimhae Airbase (AB), Korea, are shown in Table 2. The study compares 30 HAs against 63 C-5s. The much slower HAs have a slight edge in total deployment time, 96 hours against 102 hours for the C-5s, because the 500-ton payload HAs need only make one trip versus three for the 130-ton payload C-5.

From a cost standpoint, though a detailed cost comparison is outside the scope of this article, the HAs have a 3:1 advantage in fuel burned to accomplish the mission. Even in acquisition cost, the price to purchase 30 HAs, about $6B, is only 50 percent more than the $4B cost to the Reliability Enhancement and Reengineering Program for the 63 C-5s that are already in the inventory. If the comparison was made between buying 30 HAs and buying the 90 C-17s needed to accomplish this mission in the same length of time, the difference in cost is quite significant as it is estimated a 500-ton payload class HA would cost about the same as a C-17.

The ability of the HAs to operate from completely unimproved surfaces such as open fields also gives the Army more flexibility in the deployment than the C-5s. In this scenario the HAs could be operated from the drop zone at Fort Lewis, which is potentially more convenient than transporting the SBCT the 15 miles to McChord Air Force Base to be loaded on the C-5s. Similarly, when the HAs arrive in Korea they would not have to land at Kimhae AB should it be occupied to capacity by other aircraft. With full payload, but only destination fuel (fuel to fly 500 more miles) the HA is capable of operating out of a 1,500-foot circle, so if the Army wants the SBCT inserted closer to their eventual destination the HA should be able to do it.

	HA	C-5
Number of aircraft	30	63
Number of flights	30	188
Cruise (knots)	100	490
Total time (hours)	96	102
Fuel (million pounds)	30	89

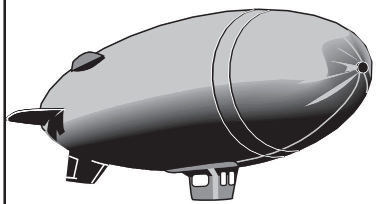
Table 2. Operational Comparison of HA versus C-5

Conclusion

Over the next several years the US Department of Defense has some very hard decisions to make regarding strategic airlift. If funding is not available to meet 54.5 MTM/D or more with conventional airlift, either sacrifices in capability must be made or an alternative will have to be found. This article presents a potentially viable alternative in the form of a hybrid aircraft.

When the author spoke to a United States Transportation Command (USTRANSCOM) officer to gauge their interest in airships he was told, "We looked at that a few years ago but dismissed it because none of the players were real companies." Today, a key player in airships is Lockheed Martin, one of the largest aerospace companies in the world. On the other hand, AMC, and therefore to a certain extent USTRANSCOM, is currently working very hard to purchase a C-17 fleet of at least 222 aircraft and may not be interested in alternatives.

Critics dismiss airships out of hand because they are not capable of flying over medium altitude threats as airplanes can. The utility of airships is more readily apparent, however, if one considers them not as a replacement for the C-17 but as a vehicle with the payload of a small ship that flies several thousand feet over the ocean at 100 knots, and can then proceed inland as far as the threat will permit, and land in a large field. They would constitute a valuable third mode of strategic transportation for



Critics dismiss airships out of hand because they are not capable of flying over medium altitude threats as airplanes can.

USTRANSCOM with speed much better than a ship and economics much better than an airplane.

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Historical Perspective

The battle is fought and decided by the quartermasters before the shooting begins.

—Field Marshal Erwin Rommel

No matter their nationality or specific service, military logisticians throughout history have understood the absolute truth represented in the above quote. Whether they were charged with supplying food for soldiers, fodder for horses, or the sinews of modern war—petroleum, oil and lubricants (POL), they have understood that victory is impossible without them—even if, sometimes, it seemed their vital contributions were forgotten or ignored. None of the great military captains of history were ignorant of logistics. From Frederick the Great to Napoleon to Patton, they all understood the link between their operations and logistics. The great captains also have all understood that history had much to teach them about the nature of the military profession. Yet, military logisticians do not often spend time studying the history of military logistics.

There are at least three general lessons from history that might prove of some use in understanding how best to prepare for the future. The first of these is the best case operationally is often the worst case logistically. The second is promises to eliminate friction and uncertainty have never come to fruition. And the third is technological change must be accompanied by organizational and intellectual change to take full advantage of new capabilities. While these lessons are not exclusive to logistics, when applied to the understanding and practice of military logistics, they provide a framework for understanding the past and planning for the future.

Colonel Karen S. Wilhelm, USAF

(Changing the Face of Unit Deployment Manager Responsibilities continued from page 36)

Objective	Tier 1 Values	Tier 2 Values	Evaluation Measures
How Best to Meet Unit Deployment Responsibilities of the Squadron	Competence	Training	Standardization of Training
		Experience	Areas of Prior Experience
		Continuity	UDM Assignment Length
	Career Field/Manning	Impacts	Implementation Impact
		Time to Implement	Time to Implement
		Flexibility	Commander Flexibility
	Career Enhancement	Professional Development	Professional Development
		Promotions	Opportunity for Promotion

Table 1. Values with Evaluation Measures

Team members formulated a set of values to assess these alternatives. In other words, what does the Air Force value if it could optimally assign UDM responsibilities. The study team agreed upon three main areas of focus that can be summarized as follows.

- The right person for the job (competence)
- The least negative impact to the Air Force (career field/ manning), and
- The right job for the person (career enhancement).

These areas were used as a starting point to develop the value hierarchy. The study team met on multiple occasions to construct the remaining pieces in the hierarchy (see Figure 1).

The percentages in each block represent weights placed on each value. The weights in the hierarchy are considered local weights because their values sum to one across each tier of the hierarchy. After developing the hierarchy, these values and their corresponding weights were reviewed and approved by the project sponsor.

With values established, the team began to develop evaluation measures. Evaluation measures provide a way to differentiate among the alternatives. Using a popular decision analysis example, if performance is a value when making an automobile purchase, an effective evaluation measure is horsepower. Every lower-level value must have at least one evaluation measure. Table 1 represents the hierarchy's values and corresponding evaluation measures.

To complete the hierarchy, the team created value functions for each evaluation measure. Value functions assist in scoring an alternative by assigning a number value (between 0 and 1) based on deliberate judging criteria. How functions were developed for the first two evaluation measures are listed in Table 1—standardization of training and areas of experience.

The competence value is broken down into three tier 2 values—training, experience, and continuity. The training value represents the importance of a well-trained UDM. Measuring how well a UDM is trained could involve surveying UDMs post training but this could only be accomplished for the *as-is* alternative. Therefore, the study team had to be more creative in developing an evaluation measure for training. After discussing training with prior UDMs, it was evident that the quality within UDM training varied widely and was highly dependent on the IDO and the readiness flight. In theory, if IDOs and readiness flights across the Air Force were required by regulation to meet a set of high standards for training UDMs, the overall quality of UDM training would vastly improve.

Assessing standardization of training would allow us to evaluate the alternatives based on their defined attributes. The level of standardization became a proxy scale for the training evaluation measure. A value function's scale is classified as either direct or proxy, and natural or constructed. A natural scale is one that has a common interpretation by the vast majority of people.[3] An

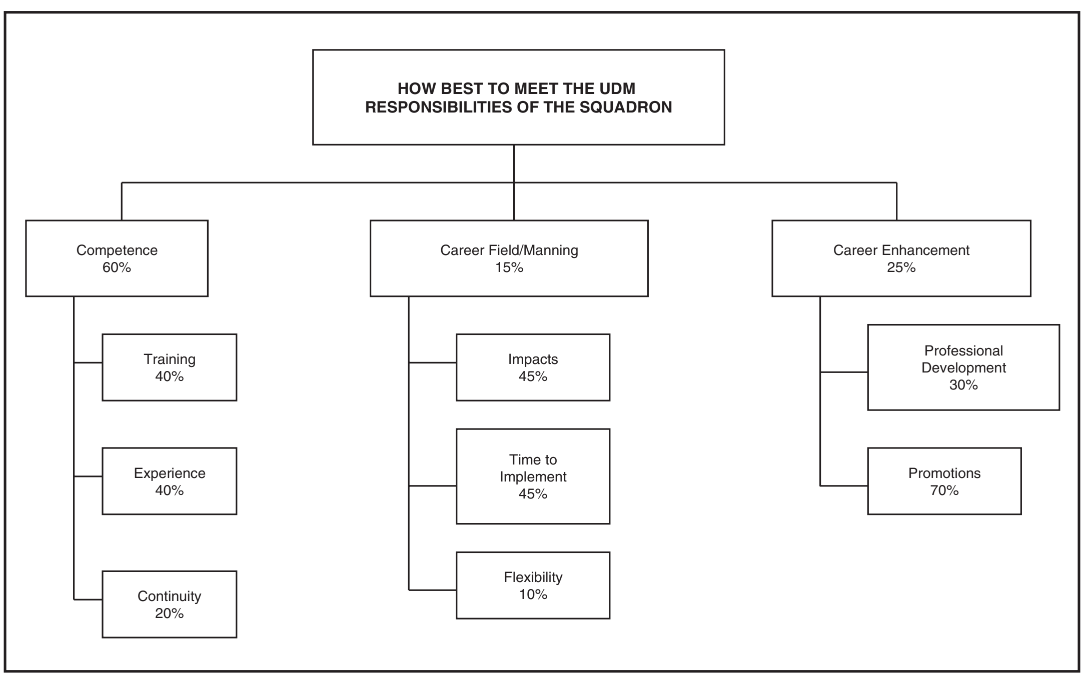

Figure 1. Value Hierarchy

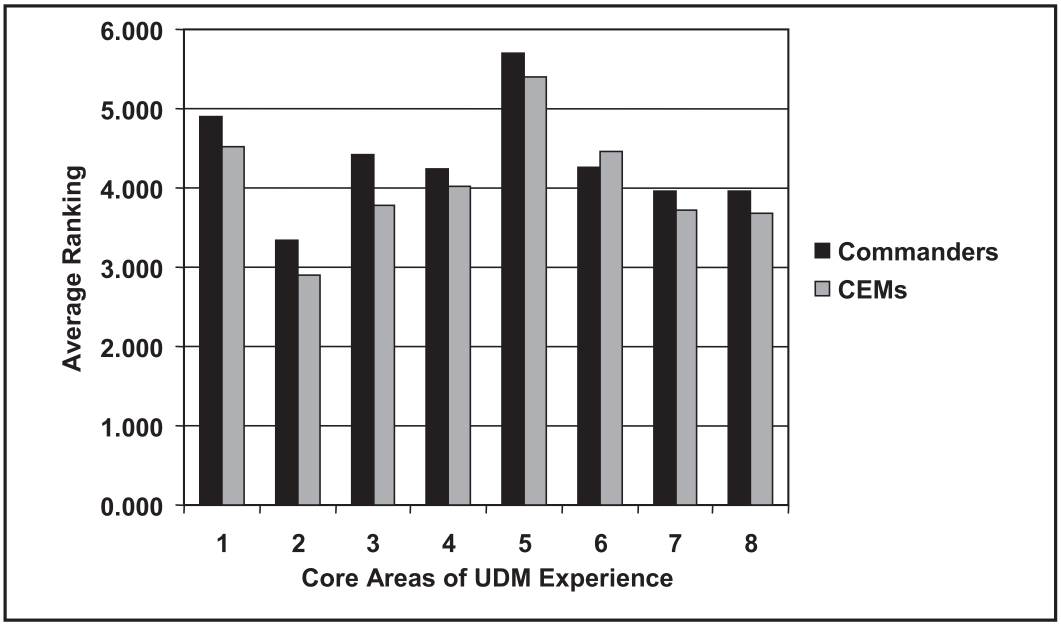

Figure 2. Training Value Function

example would be miles per gallon when comparing cars. The study team had to construct the scale for this value function. There are three possible outcomes in regard to the standardization level: Air Force, base or wing, and unit. A training program standardized at Air Force level receives the full value. A training program standardized at base or wing level receives 50 percent of the value, and a training program standardized at the unit level receives 0 percent of the value (see Figure 2).

The way the experience value function was constructed is somewhat innovative and possibly controversial among traditional VFT proponents. The study team created this value function by compiling eight core areas describing UDM experience using inputs from SMEs. Commanders and chief enlisted managers (CEMs) were asked through a survey to rank each area of experience based on importance to the UDM job. Their inputs are significant because of their direct knowledge of how prior experience can affect competence in the UDM position. The eight core knowledge areas are as follows.

- Deployments (general)
- Deployment process (for example, cargo deployment function [CDF] , personnel deployment function [PDF], pallet buildup, joint inspection [JI])
- Deployment systems (for example, the logistics module [LOGMOG])
- Readiness reporting systems (for example, the Status of Resources and Training System [SORTS] and AEF Reporting Tool [ART])
- Unit equipment
- Unit mission
- Unit taskings
- UTC management

An average ranking was computed for each core area based on the surveys (see Figure 3).

It is imperative to recognize that Figure 3 depicts average rankings; therefore, a smaller overall ranking implies a greater importance. Using these average rankings as a baseline, a value was assigned to each core knowledge area such that the total value summed to 1.00. For instance, knowledge of the deployment process had the best (lowest) overall ranking and therefore received the greatest value, 0.20. Table 2 is a compilation of all the values assigned.

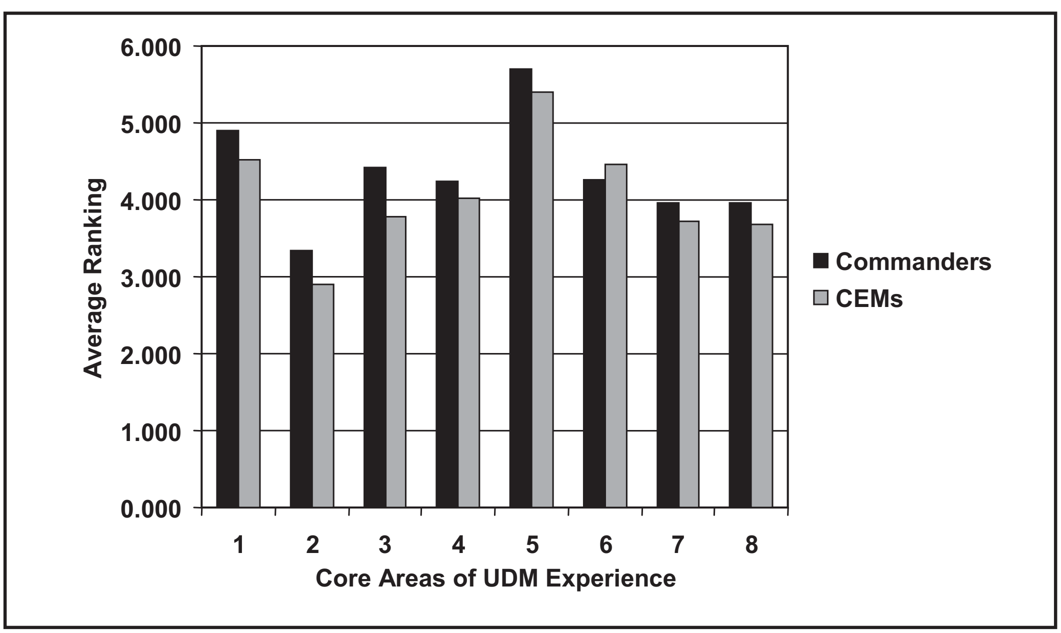

Figure 3. Average Ranking of UDM Core Areas of Experience

When scoring alternatives through this value function, credit was given to alternatives where individuals are more likely to arrive in the job with these UDM areas of experience than their counterparts from other alternatives. For example, an alternative where individuals already have general deployment knowledge as well as a familiarity with the equipment, mission, and taskings of the unit would score a 0.35 for the experience value (as in the as-is alternative where individuals are assigned from within the unit).

After all alternatives are appropriately scored through the value functions, the value's score is multiplied by the weight assigned to that value. Using the previous car example, if the decision maker weighted performance 0.25 and the value function was set such that an alternative earned a 0.5 for horsepower, then the alternative's score for performance would be 0.125. Summing every value's score for an alternative will produce an overall weighted *score* between 0 and 1 for that alternative. The weighted scores differentiate the alternatives and assist the decision maker in choosing from among the alternatives.

The study team carefully defined the attributes associated with each alternative. In this way, the study team was able to objectively score each alternative through the hierarchy based on predefined attributes and the information gathered through literature review, personal interviews with SMEs, and survey responses. Surveys were conducted to gain an understanding of the current UDM environment. The surveys were distributed to commanders, CEMs, and UDMs stationed at 1,514 units Air Force-wide. The surveys assisted the study team in scoring the as-is alternative and helped identify many concerns existing out in the field. Figure 4 depicts the final scores based on the analysis.

Sensitivity Analysis

Sensitivity analysis highlights how changes in certain model assumptions impact the ranking of alternatives. The sensitivity analysis in this section

UDM Areas of Experience	Value
1. Deployments (general)	0.05
2. Deployment process (for example, CDF, PDF, Pallet build-up, and JI)	0.20
3. Deployment systems (for example, LOGMOD)	0.15
4. Readiness reporting systems (for example, SORTS and ART)	0.15
5. Unit equipment	0.05
6. Unit mission	0.10
7. Unit taskings	0.15
8. UTC management	0.15
TOTAL	1.00

Table 2. Values Assigned to Areas of Experience

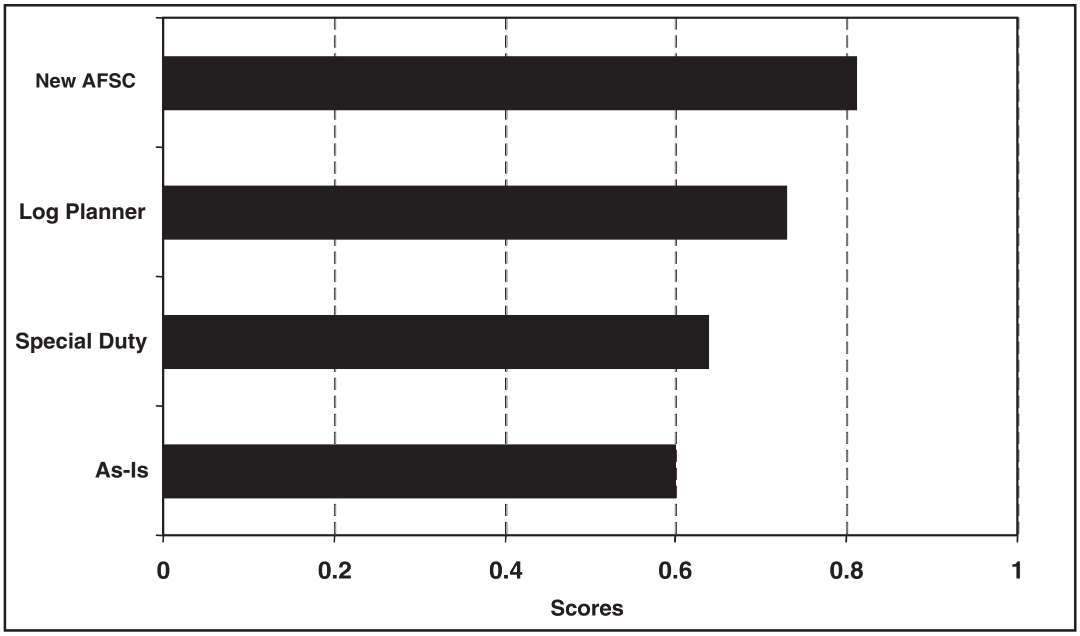

Figure 4. Scoring Alternatives

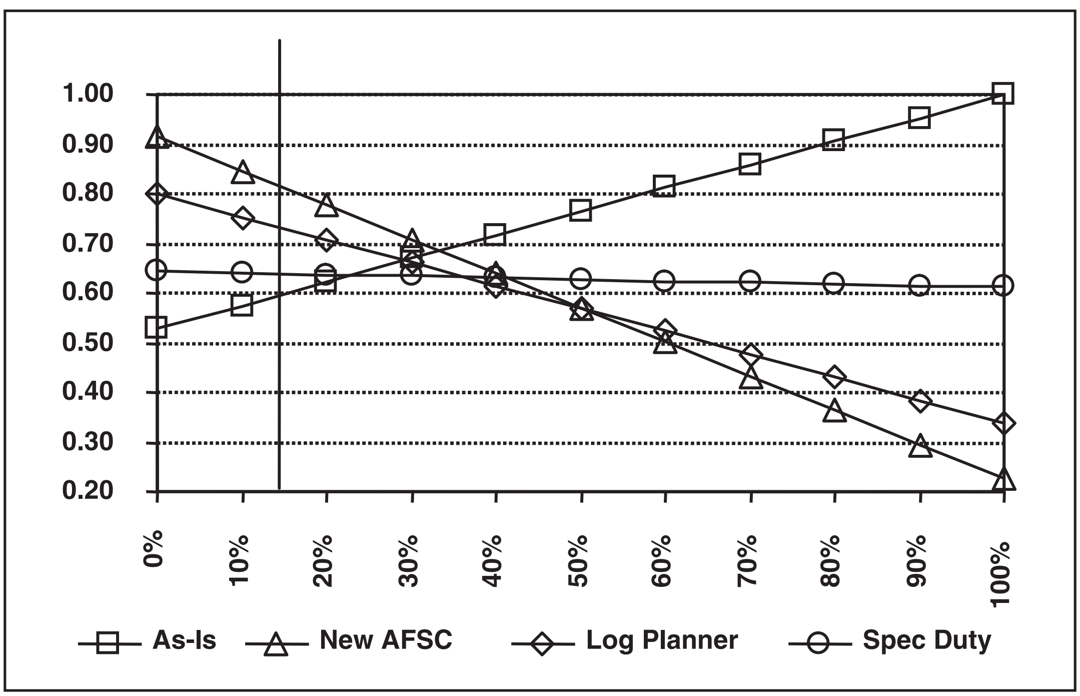

Figure 5. Sensitivity Analysis Graph

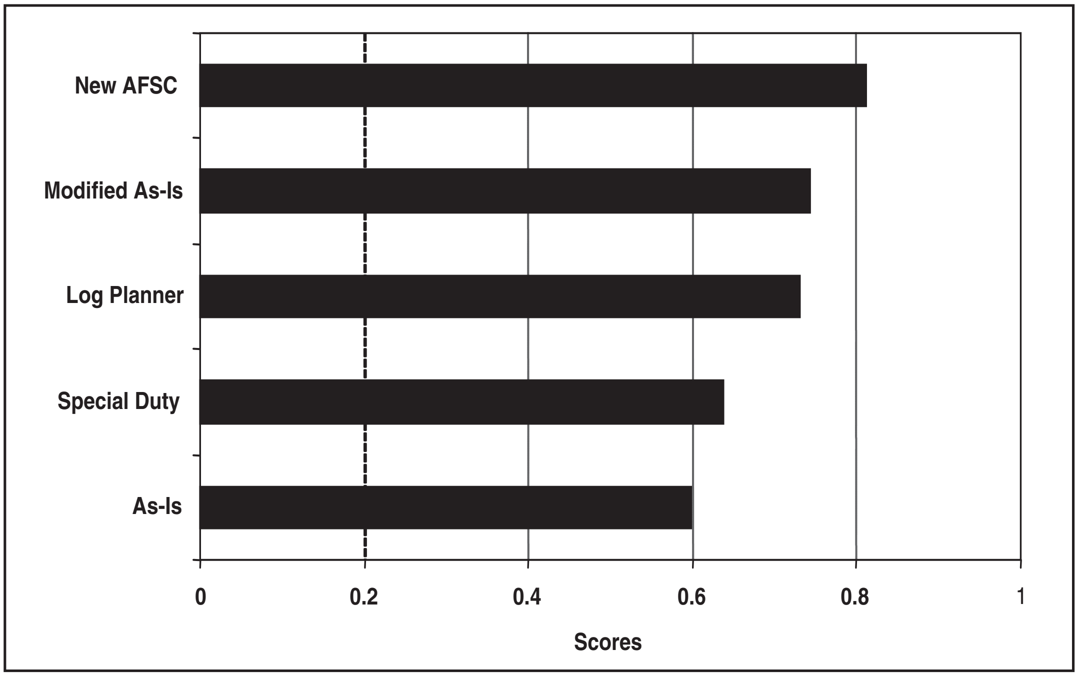

Figure 6. Scoring of Alternatives with Modified As-Is

focuses on the weights within the hierarchy. It answers the question, *what if the decision maker isn't certain about the weights?* The focus in this example is on local sensitivity analysis because the hierarchy was weighted locally. This means the decision-making body first weighed the hierarchy between the values in the first tier, and then focused on weights between the values within each branch of the second tier. The career field or manning value is used to illustrate the power of sensitivity analysis. Sensitivity analysis allows the weighting on career field or manning to vary in order to determine what effect this would have on the outcome. The weight on career field or manning will vary between 0 and 100 percent and the remaining weight will be distributed proportionally between the two remaining values within the first tier (competence and career enhancement). A plot representing the alternatives is shown in Figure 5.

The vertical line represents the original weight placed on career field or manning. With career field or manning's weight set at its original value of 15 percent, the new AFSC alternative receives the greatest value at 0.812. The new AFSC alternative receives the highest score with the weighting on career field or manning varying between 0 and 34 percent. When the career field or manning value is weighted at 35 percent and on up to 100 percent, the "as-is" alternative becomes the most attractive option. This sensitivity analysis illustrates the model is relatively insensitive to reasonable variations in the weighting place on career field or manning, allowing the decision-making body to have more confidence in the outcome.

Conclusions

This analysis provides valuable insight to the decision maker or decision-making body. The results tell the decision-making body that, based on the inputs to this model, creating a new AFSC will provide the greatest value to the Air Force. It focuses on the value inherent in the attributes of each alternative. It does not account for possible limiting constraints. For example, creating a new AFSC requires new manpower authorizations or converting existing authorizations. The requirement to fill these authorizations may make this alternative infeasible. This particular constraint caused the study team to recommend an entirely different alternative. Modifying the as-is alternative to incorporate some mandates that address problem areas discovered through this study would make the as-is much more attractive. Developing an Air Force-wide UDM training program and increasing assignment length from 18 months to 24 months, raises the *as-is* alternative score from 0.599 to 0.743. These changes make the modified as-is alternative the second highest scoring alternative, as shown is Figure 6.

This type of decision-making model is an excellent tool that provides valuable insight into complex decisions. It allows the decision maker or decision-making body to reduce the decision into manageable parts and consider each part in an objective forum as demonstrated in this study on the assignment of UDM responsibilities.

The sponsor of this study will use the recommendations to improve future readiness management practices. Air Staff requested a manpower study from the Air Force Manpower Agency (AFMA) that will consider giving squadrons credit for UDM work being performed. AFMA will use this UDM report as their starting point.

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Military Logistics and the Warfighter

I think we can all agree there is a relationship between the function of military logistics and the warfighter. What is that relationship, and is it correctly defined? In the early 1960s, there was a stated relationship between logistics and the weapons systems: military logistics *support* the weapons system. At that time, the subject of military logistics was fairly new and, with little ongoing research, very slow in providing greater *understanding* about it. Therefore, during that period, this definition of relationship seemed appropriate. It was not until the late 1970s that several advocates of military logistics came to the realization that logistics *support* of the weapon system was actually creating and sustaining warfighting capability. This warfighting capability was provided to the combat forces in the form of continuing availability of operational weapon systems (the tools of war). This new awareness set up another definition of the relationship: *military logistics creates and sustains warfighting capability.* While many heard the words, few realized their implications.

The level of warfighting capability that logistics provides the combat forces determines the extent to which war can be waged. This, in turn, limits and shapes how the war will be waged. Warfighting capability is *embedded* in the design of all weapon systems. Advancing technology increases speed, range, maneuverability, ceiling, and firepower, all of which provide more lethal and accurately guided munitions, stealth, and other offensive and defensive warfighting capabilities. They will be embedded into the design of future weapon systems. It is the weapon systems that contain the warfighting capability of military forces. The strength of military forces is no longer measured by the number of men *under arms*. Today, military forces are measured by the number—and warfighting capabilities—of their weapon systems. The Department of Defense has yet to adequately define and manage the total logistics environment (those activities and resources required to create and sustain warfighting capability). While it is said that armies travel on their stomachs, what is usually left unsaid is they perform on the basis of their logistics competency.

Today, as most of you are aware, we have another, more recently defined relationship: *military logistics supports the warfighter*. We know military logistics creates and sustains warfighting capability. We can assume the warfighter fights wars. It would, therefore, appear reasonable to suggest that in order for one to be a warfighter (a pilot in this case) he or she must have the capability to wage war. While weapon systems are designed and created to wage war, people are not. Therefore, in order to become warfighters, pilots must be provided with some level or amount of warfighting capability. I would submit that by providing the pilot with an operational weapon system, which allows him or her to utilize its warfighting capability, *military logistics creates the warfighter*. It does not *support* the warfighter; it *creates* the warfighter. This transformation occurs when a checked-out pilot starts the engine. At that point, the pilot is in control of the weapon system and its warfighting capability. The pilot is now the warfighter. Without the warfighting capability, which the weapons system provides, a pilot is a pilot.

Military logistics creates and sustains warfighting capability; by doing so, military logistics creates and sustains the warfighter.

Colonel Fred Gluck, USAF, Retired

For Want of a Spanner

A curious minor logistical mystery of Royal Air Force history in World War II was and is the shortage of hand tools. This lasted well into 1943, 4 years after the war began and 9 years after rearmament started in 1934.

Before wartime expansion, fitters and riggers did their initial course at No. 1 Technical Training School at Habton. They specialized either as engine fitters or as airframe riggers. Upon completion of the course they were sent to squadrons where in 7 years their education was completed.

At the squadron they reported to A, B, or C Flight where they were issued a toolkit. If they were transferred from one flight to another, they had to turn in their toolbox and have the contents accounted for before proceeding across the street to draw another set from their new flight. In biplane days, a fitter or a rigger assigned to a two-seater not only acted as the gunner, but in colonial theaters lashed his toolbox to the wing next to the fuselage in case of a forced landing.

What makes the case of the missing hand tools so intriguing is that the historical documentation concerning the ordering of such necessary items has disappeared (meaning it has either been destroyed or it has been filed with the papers of a successor organization of unlikely title).

The first clue to the problem came from the Operational Record Book of a repair and salvage unit in the Middle East in 1940 which opened by noting that of the RSU's 62 personnel, only 25 had tools. So they were happy to pass on salvaged aircraft to whoever claimed them.

What this meant was that in a theater then desperate for serviceable aircraft, many were standing idle because the necessary repairs could not be made *for want of a spanner*, let alone the necessary spares.

But the matter is important because in 1943 in Burma (South-East Asia Command or SEAC), the Beaufighters of No. 26 Squadron only sortied once every 18 days due to lack of tools and spares.

The fact that the RAF had insisted on standardized nuts, bolts, and other fittings meant that special tools were not needed. Unserviceability was due to the unavailability of regular tools.

Robin Higham, PhD

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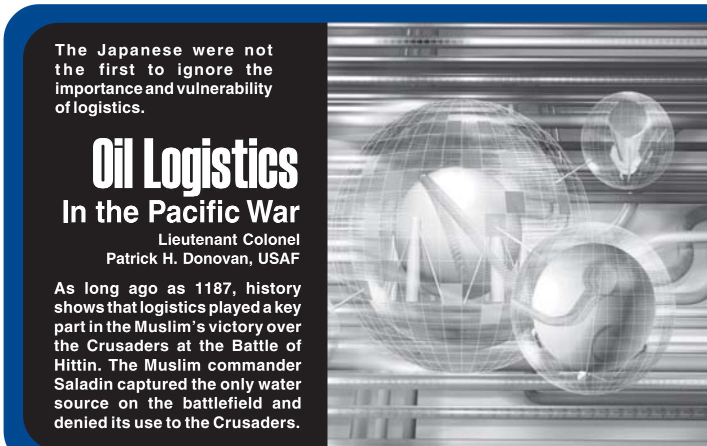
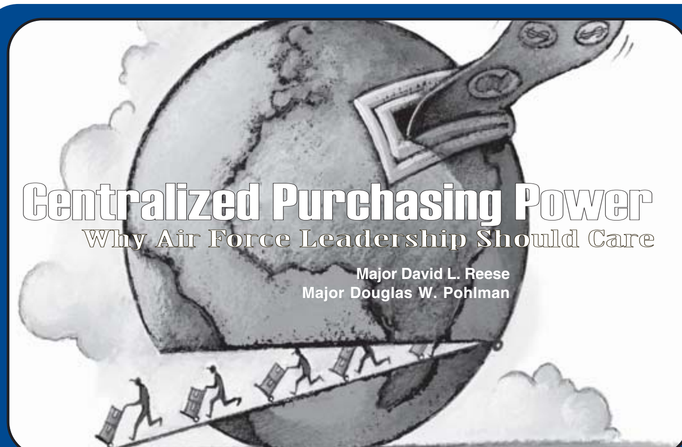
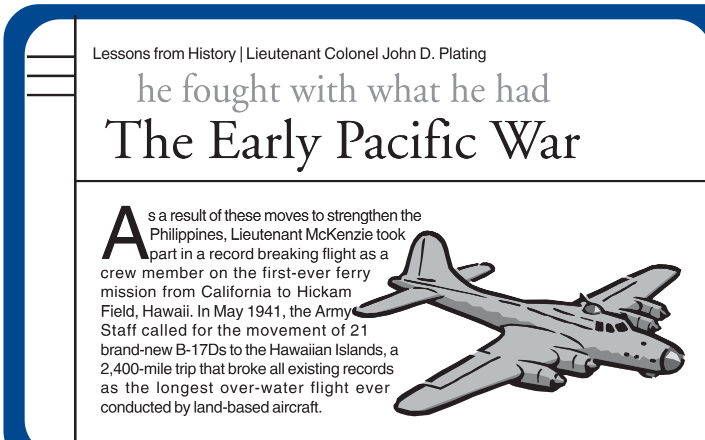
The Editorial Advisory Board selected "Global Combat Support System: A Must for the Joint Warfighting Commander"—written by Lieutenant Colonel Bryan T. Newkirk, USA and Colonel Karen W. Currie, USAF, Vol XXVIII, No 3—as the most significant article to appear in the *Air Force Journal of Logistics* in 2004.



"Oil Logistics in the Pacific War"—written by Lieutenant Colonel Patrick H. Donovan, USAF—was chosen as the most significant historical article to appear in the *Air Force Journal of Logistics* in 2004.



The Editorial Advisory Board selected "Centralized Purchasing Power: Why Air Force Leadership Should Care"—written by Major David L. Reese, USAF and Major Douglas W. Pohlman, USAF—as the most significant article to appear in Vol XXIX, No 1 of the *Air Force Journal of Logistics*.



The Editorial Advisory Board selected "The Early Pacific War: He Fought With What He Had"—written by Lieutenant Colonel John D. Plating, USAF—as the most significant article to appear in Vol XXIX, No 2 of the *Air Force Journal of Logistics*.